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WEEKLY 20 March 2021

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Capitalism caused the climate crisis. Guided by the right values, it can help save us

ESTABLISHING a good degree of pandemic resilience would have cost less than the economic output lost in just a single day of the covid-19 crisis. That missed opportunity is one indictment of market failings among many that former Bank of Canada and Bank of England governor Mark Carney advances in our interview with him this week (see page 44).

Another, perhaps the most troubling, is the inability of markets to value the natural world. How is it that we can put a value on Amazon, the company, yet only ascribe value to the Amazon rainforest by logging it and stripping it bare?

Carney's critiques are worth listening to. He has sat at the top table of global capitalism for the past decade and a half. We have become in thrall, he says, to a dangerous market fundamentalism that

fails to find value in things of real worth to all of us, things that create long-term prosperity: resilience, sustainability and equality of opportunity among them.

Failure to invest in pandemic controls before covid-19 is one example of this "crisis of value". The growing climate and environmental crisis is another.

"We are in thrall to a dangerous market fundamentalism that fails to value the things we do"

The technological solutions we need to reach net-zero carbon emissions by mid-century largely already exist. With a new US administration in place, the political momentum for change is gathering, too. Aligning market values with our values in the climate fight is now the missing piece.

Carney is at the centre of efforts to remedy that in the run-up to the crucial COP26 climate talks in the UK this November. Central to it all is the thing that oils all efficient markets: information. Establishing reporting requirements, for example, that make it clear how firms' investment strategies fit with net-zero might not sound heroic, but it would allow everyone to make investment decisions based on their own, and society's, values.

Carney found himself embroiled in controversy last month over the definition of net-zero investments used by the financial company he now works for. However, that only underscores the difficulty, and importance, of what is needed: robust action to rework markets to ensure they are transparently working for the benefit of us all. ■

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Syndication

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Email tca-articlesales@tribpub.com

Subscriptions

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One year print subscription (51 issues) UK £198

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Post New Scientist, Rockwood House, Perrymount Road,

Haywards Heath, West Sussex RH16 3DH

© 2021 New Scientist Ltd, England. New Scientist is published weekly by New Scientist Ltd. ISSN 0262 4079. New Scientist (Online) ISSN 2059 5387. Registered at the Post Office as a newspaper and printed in England by Precision Colour Printing Ltd

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MICHIO KAKU



DAVID MIZINARSHVILI/TASS/PA IMAGES

A nurse holds a vial containing the AstraZeneca vaccine

He says that older people and people with pre-existing health conditions, who are more at risk of blood clots generally, have been prioritised for the vaccine, which may have skewed the apparent side effects. He would like to see a comparison with a control group that has the same characteristics as the people so far vaccinated.

"Many thousands of people develop blood clots annually in the EU for different reasons"

The International Society on Thrombosis and Haemostasis recommends that all eligible adults continue to receive their covid-19 vaccinations. "At this time, the small number of reported thrombotic events relative to the millions of administered COVID-19 vaccinations does not suggest a direct link," it said in a statement.

"In weighing up the merits of a medical intervention, it's really important to consider both sides of the argument: how risky is it for someone to have it versus how risky is it for them not to," says Lucy Walker at University College London. "An increased risk of thrombosis is one of the known complications of [coronavirus] infection. The vaccines we have are incredibly good at preventing the illness caused by this virus. They will therefore prevent people from having thrombosis associated with the infection itself."

The decision to halt use of the vaccine could have wider consequences, adds Walker. One is that it could lower vaccine uptake in general by increasing anxiety about jabs. To get the upper hand with the coronavirus, we also need to vaccinate people as quickly as possible to suppress the evolution of dangerous variants. "To have stocks of a safe, effective vaccine not being used, through an abundance of caution, potentially hinders this mission," she says. ■

Vaccine safety

Blood clot controversy

Several countries halt use of Oxford/AstraZeneca vaccine over blood clot fears, despite experts saying it is safe, reports **Layal Liverpool**

A NUMBER of European nations, including Germany, France, Italy and Sweden, have suspended use of the Oxford/AstraZeneca covid-19 vaccine over blood clot concerns.

The World Health Organization and the European Medicines Agency (EMA) have both emphasised that there is currently no evidence linking the vaccine to blood clots and recommend that countries continue using it. As *New Scientist* went to press, both organisations were meeting to review the vaccine, with a statement expected imminently.

Among 17 million people who have received the vaccine in the EU and the UK, 15 cases of deep-vein thrombosis (DVT) and 22 cases of pulmonary embolism have been reported as of 8 March, AstraZeneca said in a statement on 14 March. DVT is a blood clot

in a vein, which has the potential to travel to the lungs, causing a blockage, or what is known as a pulmonary embolism.

"Many thousands of people develop blood clots annually in the EU for different reasons," the EMA said in a statement. The number of blood clotting incidents in vaccinated people "seems not to be higher than that seen in the general population".

In Germany, the Paul Ehrlich Institute, which advises the government on covid-19, said it had recommended the temporary suspension of the vaccine following a "noticeable increase" in cases of cerebral venous sinus thrombosis (CVST),

a blood clot in a major brain vessel, soon after vaccinations.

Germany's health minister, Jens Spahn, said at a press conference on 15 March that there had been seven reported cases that may be related to CVST out of 1.6 million vaccinations in Germany. Estimates of how many incidences of CVST you might expect in the general population over a year vary from two to five cases per million people to more than 15 cases per million, depending on the study.

"There is absolutely no data that supports [the German government's] decision," says César Muñoz-Fontela at the Bernhard Nocht Institute for Tropical Medicine in Germany.



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Vaccine roll-out

US won't delay second dose

Countries disagree on coronavirus vaccination strategies amid warnings that a long time between shots could create lethal variants, says **Graham Lawton**

THE UK's controversial decision to increase the time between covid-19 vaccine doses has been thrust back under the spotlight after the US hasn't followed suit, amid warnings that the strategy may backfire. However, the UK is no longer alone in its decision, with Canada and Germany both choosing to follow a similar plan.

In December, the UK made the surprise decision to lengthen the interval between doses of the Oxford/AstraZeneca and Pfizer/BioNTech vaccines from the recommended three or four weeks to 12 weeks.

The rationale was that this would maximise the impact of limited supplies of the vaccine. By allowing twice as many people to be given a first dose, it would theoretically produce broader levels of protection across the population.

The decision was based on recommendations from a government advisory body, the Joint Committee on Vaccination and Immunisation (JCVI), which calculated that the level of protection from the first dose was quite high and that a 12-week gap would save 3000 to 4000 more lives per million doses of vaccine.

The strategy appears to be working, with early results from the UK's vaccination programme described as "spectacular". One study of the entire population of Scotland found that by the fifth week after a first dose, the Oxford/AstraZeneca jab reduced the risk of hospitalisation by 94 per cent and the Pfizer/BioNTech vaccine by 85 per cent.

A similar study in Israel found that the first dose of the Pfizer/BioNTech vaccine was 78 per cent effective at preventing hospitalisation after 21 days.

There is growing clamour in the US to pivot to the UK model.

Although the US is managing to roll out about 2 million vaccines a day, it is being limited by vaccine supply, said Nancy Messonnier, director of the National Center for Immunization and Respiratory Diseases (NCIRD), at a JAMA Network webinar on 26 February.

"You see op-eds and talking heads on TV news programmes saying we should be doing what the Brits are doing," says John Moore at Weill Cornell Medicine in New York. But the US won't be changing course, he says.

"There are talking heads on the news saying the US should do what the Brits are doing – but we won't"

On 1 March, the US Centers for Disease Control and Prevention held an online meeting of its own immunisation advisory body, which discussed, among other things, the evidence for and against extending the interval between doses of the mRNA vaccines made by Pfizer/BioNTech and Moderna – both approved in the US. It came down in favour of sticking with the recommended interval, which is three weeks for Pfizer/BioNTech and four weeks for Moderna, and no more than six weeks for either.

At the meeting, Kathleen Dooling at NCIRD laid out the pros and cons of delaying a second dose. On the upside, it could, in theory, protect more people in the short term, she said. But on the downside, it could leave people vulnerable to the new variants and increase the risk of yet more variants emerging.

In addition, the strength and duration of protection from a single dose remain uncertain. On balance, she said, there was "insufficient data to increase the recommended interval".

REUTERS/MARCO BELLO



A healthcare worker gives a coronavirus vaccine to a woman in Miami, Florida

"I completely agree with that," says Moore, who recently wrote an article in the journal *JAMA* specifying the arguments against a longer interval.

He detailed the fact that, even though a single dose of vaccine is protective against the original SARS-CoV-2 virus, it is less so against some of the new variants. Of particular concern are the variants that were first reported in South Africa (named B.1.351) and Brazil (P.1). Both carry a spike protein mutation called E484K, which makes them somewhat resistant to vaccine-induced antibodies, especially at lower antibody concentrations.

"You are going to need the strongest possible antibody response to deal with them," says Moore, and that means giving the second dose to schedule.

94%

Decrease in risk of hospitalisation due to covid-19 in Scotland five weeks after a single dose of the Oxford/AstraZeneca vaccine

One dose of vaccine may be enough for some

Clare Wilson



Experiments in the lab show that a single dose of mRNA vaccine isn't enough to stop these variants from replicating almost unimpeded, he says. "They just blow past it."

"If they start spreading, you're in trouble," says Moore. B.1.351 and P.1 are already present in the UK, and the E484K mutation has also been spotted in the B.1.1.7 variant, first discovered in the UK, which hasn't so far been found to be resistant to vaccines.

Another argument against longer delay is that people who are part-vaccinated are a potential breeding ground for yet more variants, says Moore. A strong antibody response should stop the virus in its tracks, while zero antibody response allows it to replicate with ease. But a half-hearted one would put

selection pressure on the virus to evolve. This hasn't yet been observed, but needs to be considered, says Moore.

John Robertson at the University of Nottingham, UK, agrees. Writing in *The Lancet*, he says: "the UK's delayed second dose could strongly favour the emergence of consequential SARS-CoV-2 variants." This risks perpetuating rather than ending the pandemic, he says. "Why make a short-term decision that could have really bad long-term consequences?" says Moore.

The UK strategy still has its supporters. Immunologist Eleanor Riley at the University of Edinburgh, UK, was a vocal proponent of the decision. "I have not yet seen any data that would persuade me that JCVI should change tack," she says.

She points out that a single dose of either of the vaccines approved in the UK provokes an antibody response at least as strong as that induced by natural infection. "Many previously infected people have weak antibody responses. So, currently, the greatest selection pressure from suboptimal antibody responses is likely

Reminder cards in the UK tell people the date of their second vaccine shot



CHRIS JACKSON/GETTY IMAGES

coming from people who have been infected. Currently there are many, many millions more of them worldwide than there are people who have been vaccinated. So one could argue that the sooner everyone has at least one shot of the vaccine, the better." (For more on the effectiveness of a single dose, see right.)

She also points to the research from Scotland suggesting that the UK vaccine programme is working. "I think the data from across the UK are supporting the rapid roll out of single doses as the fastest way to reduce deaths."

The JCVI is also sticking to its guns. "Data to date demonstrates one dose of either Pfizer or AstraZeneca vaccines are giving high levels of protection against severe disease – hospitalisations and deaths. So currently [we have] no plans to change our advice about delaying the second dose for up to 12 weeks," says JCVI deputy chairman Anthony Harnden at the University of Oxford.

Meanwhile, on 3 March, Canada's National Advisory Committee on Immunization recommended that the interval between the first and second doses of all three two-dose vaccines approved for use in the country should be stretched to a maximum of four months.

The committee acknowledged in a statement that data didn't exist for four months of effectiveness after just one dose, but said "the first two months of real-world effectiveness are showing sustained high levels of protection".

Germany has also opted to recommend an extended interval of six and 12 weeks between the Pfizer/BioNTech and Oxford/AstraZeneca doses, respectively.

Only time will tell which is the right strategy, says Moore. ■

A SINGLE dose of a coronavirus vaccine may be all that is needed for people who have already been infected with covid-19.

A small study suggests that in people receiving the Pfizer/BioNTech vaccine, the body's response to natural infection with SARS-CoV-2 seems to act like a first dose of the vaccine.

Mark Mulligan at New York University and his colleagues tracked antibody levels in 32 people who were given both doses of the vaccine, and one person who had both doses of the Moderna jab. About half had previously contracted covid-19.

About two weeks after a first dose, people who had recovered from covid-19 had antibody levels similar to or higher than those of people who had never been infected but had received both doses. The results were announced on 9 March online at the Conference on Retroviruses and Opportunistic Infections.

A separate study of 109 people in New York who had received either the Pfizer/BioNTech or the Moderna vaccine revealed similar findings.

Alongside antibodies, other aspects of the immune response may still be improved by two doses, such as T-cell activity, says Stephen Evans at the London School of Hygiene & Tropical Medicine. "If you're offered two doses, I would take them even if I thought I had been infected, because it would probably boost my overall response and it might make me more likely to respond to a variant," he says.

The US Centers For Disease Control and Prevention hasn't changed its guidance, which is that people with a confirmed, recent acute covid-19 infection may choose to temporarily delay vaccination, if desired. ■

Coronavirus surge

Global cases on the rise again

The B.1.1.7 coronavirus variant first seen in the UK seems set to cause a surge

Michael Le Page

THE B.1.1.7 coronavirus variant first spotted in the UK is poised to cause a surge in cases worldwide. In many areas of Europe and North America, the variant, which is more transmissible, is now responsible for most new coronavirus infections.

Globally, since late February there has been a small uptick in coronavirus infections.

"In Italy, bars reopened in February and, combined with B.1.1.7, they are seeing a rise in cases"

Before this, case numbers had been falling sharply. The big question is what happens next.

"There will almost definitely be a resurgence almost everywhere," says Nick Davies at the London School of Hygiene & Tropical Medicine. His team's modelling suggests that this could include the UK if lockdown measures are relaxed too quickly.

A global surge could also be driven by the B.1.351 variant first seen in South Africa and the P.1 variant initially spotted in Brazil, says Davies.

Others disagree. "Another [global] wave due to B.1.1.7 is far from inevitable," says David Dowdy at Johns Hopkins Bloomberg School of Public Health in Baltimore, Maryland. Other factors are moving in a positive direction, he says. More people are getting vaccinated, the weather is getting warmer in the northern hemisphere and there is a gradual build-up of population immunity.

The B.1.1.7 variant already contributed to a big second wave of cases in the UK in December, forcing the UK government to impose a strict lockdown in England in January. At the start of this wave, the B.1.1.7 variant

was responsible for only a small proportion of cases. It now causes 98 per cent of all cases in the UK.

Much the same thing happened in Ireland and Portugal, which also imposed lockdowns as a result.

Now, cases are starting to surge in other countries, including the Czech Republic, Italy, Poland and Hungary. These countries don't do much genome sequencing to identify the virus variant detected in new cases, so it isn't clear how big a role B.1.1.7 has played, but reports suggest it is responsible for many, if not most, cases.

"In Italy, bars and restaurants reopened in February and, combined with a high prevalence of B.1.1.7, they are seeing a steep rise in new cases again," says Tom Wenseleers at the Catholic University of Leuven (KUL) in Belgium.

An ominous pattern is emerging in places doing more sequencing. Although the number of cases due to older variants is falling, the number of cases due to B.1.1.7 is rising exponentially. Where this trend continues, the overall number of cases climbs again.

Belgium, for instance, is seeing an increase in the overall number



OLIVIER MATTHYS/BLOOMBERG VIA GETTY IMAGES

of cases that is almost entirely due to B.1.1.7, says Wenseleers (see graph, below).

The UK has shown that lockdowns can halt the spread of variants, but in many countries, including Germany, there is pressure to ease restrictions. "The main risk would be to reopen too many sectors again at the same time," says Wenseleers.

Visitors wait in line at a mass vaccination centre in Brussels, Belgium

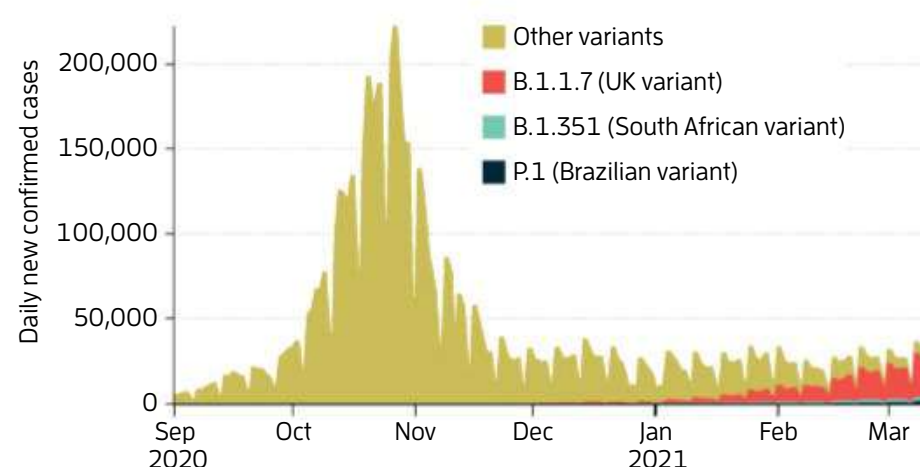
Vaccination also works. In Israel, where B.1.1.7 accounts for more than 80 per cent of cases, infection rates are falling fast about one month after a lockdown ended. This is almost certainly because nearly 90 per cent of people aged over 16 have been vaccinated.

Countries such as the US, where a third of the population has had one dose, still haven't vaccinated a high-enough proportion of the population to prevent a resurgence of cases in the coming weeks. The vaccination rates in most of Europe are far lower, and will be further slowed now the use of the Oxford/AstraZeneca vaccine has been suspended in several countries (see page 7).

In most of the rest of the world, vaccination has barely begun and little is known about the prevalence of variants, making it difficult to predict future trends. ■

Estimated new daily infections by SARS-CoV-2 variants in Belgium

Belgium is seeing a rise in overall coronavirus cases that is almost entirely due to the B.1.1.7 variant, first identified in the UK





New Scientist Escape Pod

Hello and welcome to the Escape Pod. Your flight will last about 15 minutes and we expect no turbulence, just a smooth, pleasant ride.

This lockdown podcast doesn't include any references to coronaviruses or other unpleasant happenings on the planet below. The Escape Pod is pure, well, escapism. Sit back, relax and let hosts Rowan Hooper, Anna Demming and Timothy Revell whisk your mind away to worlds of inspiration and distraction.

And when you're ready to come back down to Earth and hear about what's going on in the world, don't forget the *New Scientist* Weekly podcast – your audio guide to all the essential science news of the week.

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Rowan
Hooper



Anna
Demming



Timothy
Revell

Biology

Hibernation could be key to slowing ageing

Michael Le Page

A KEY sign of ageing slows right down when marmots are hibernating. This suggests we might be able to induce similar changes to put humans in suspended animation for long-distance space travel.

“They may not age during this process,” says Gabriela Pinho at the University of California, Los Angeles (UCLA). Her team has been studying wild yellow-bellied marmots – a kind of ground squirrel – in Colorado. These animals hibernate for up to eight months a year, dropping their body temperature as low as 5°C.

Starting in 2004, Pinho and her colleagues followed 73 female marmots from birth to death, taking regular blood samples. These were analysed by Steve Horvath, also at UCLA, who has shown that the age of many species can be estimated from epigenetic changes in blood cells – essentially, a build-up of chemical labels added to certain DNA sequences.

These changes usually accumulate steadily over an animal’s lifetime. But in the

8
Yellow-bellied marmots can hibernate for this many months

marmots, there is a striking cyclical pattern, says Pinho, with most changes occurring in summer when the animals are active ([bioRxiv, doi.org/fz6d](https://doi.org/10.1101/2021.03.18.438661)).

The finding suggests that the ageing process slows during hibernation, and Pinho thinks this is likely to be true for all animals that hibernate. “When I first saw this, I was like, ‘Wow, what we suspected is actually happening,’” she says.

The results could help us



SHUTTERSTOCK/IVORKUCHTA

induce hibernation in people, both for medical reasons and for space travel. Several studies have shown that hibernation protects rodents and human cells against radiation damage, says Pinho, so it could help human space exploration. What had been less clear is whether it also slows ageing.

This matters if we want to travel beyond Mars, says John Bradford at SpaceWorks in Atlanta, Georgia, whose team has studied the possibility of putting people into stasis for NASA. “This delayed ageing with hibernation would be critical,” he says. “Identifying any mechanisms in animals that could be delaying ageing in low metabolic conditions is obviously needed in order to understand how this may translate to humans.”

Hibernating animals do tend to live longer than other similarly sized animals, says Bradford, but this could just be because they are less likely to be caught by predators or be exposed to harsh conditions.

“The finding that certain ageing-related epigenetic

Wild yellow-bellied marmots are found in Colorado

changes slow down during seasonal hibernation is very exciting and consistent with the hypothesis that ageing slows down during hibernation,” says Sinisa Hrvatin at Harvard Medical School, whose team has discovered a “brain switch” that seems to induce hibernation.

But ageing is very complex, says Hrvatin. We need to explore whether inducing hibernation in animals that don’t usually do it extends lifespan, he says.

“It is an amazing study,” says Christopher Turbill at Western Sydney University in Australia, who has shown that hibernation slows another sign of ageing, the shortening of the protective telomeres at the ends of our chromosomes.

A correlation between winter and rate of ageing doesn’t show that hibernation is the key factor, says Turbill. However, when combined with his work, it adds weight to the idea that hibernation is responsible. ■

Geology

Really ancient rocks suggest early Earth was a melted mess

Karina Shah

CHEMICAL signatures in 3.7-billion-year-old basalt rocks from Greenland support the long-held idea that our planet was once almost entirely molten.

We know very little about what early Earth looked like – but one suggestion is that at several times it was one giant magma ocean. These molten-Earth periods were probably caused by a series of huge impacts with other objects in our solar system that each generated enough energy to melt our planet’s interior. One collision may have formed the moon.

Now, Helen Williams at the University of Cambridge and her colleagues have found evidence of these early magma oceans in ancient rocks.

They collected samples of 3.7-billion-year-old basalt from the Isua supracrustal belt, an area of rocks in south-west Greenland, and measured the iron isotopes in them using chromatography and mass spectroscopy. They found unusually high levels of heavy iron isotopes – lighter ones are commonly found in basalt rocks.

These heavy iron isotopes are typical of the high pressures of magma ocean crystallisation, says Williams. “We are looking at a real signature of [this] process.”

The team found that the Greenland rocks contained iron-rich minerals that hold a history of repeated crystallisation from magma oceans beginning as early as 4.1 billion years ago. Some of the minerals may have formed at least 700 kilometres below Earth’s surface (*Science Advances*, [doi.org/f2jg](https://doi.org/10.1126/sciadv.abe2199)).

Although this is the earliest evidence of these magma oceans, the team is confident that they existed before this. But Williams says it is difficult to find ancient rocks from Earth’s earliest days that would preserve this evidence. ■

8 days | 27 August and 8 October 2021

Saint Petersburg: The history of Russian science

Explore the history of Russian science, from Peter the Great's visionary creation of the Russian Academy of Sciences in 1755, through the fraught years of Soviet transformation, to a present-day dominated by thoughts of space exploration and settlement. Led by art and architecture expert Andrew Spira with Simon Ings, author of *Stalin and the Scientists*, and *New Scientist* writer.

Visit museums, cathedrals and sites made famous by the likes of Pavlov, Vavilov, Dokuchaev and Mendeleev. Discover the often overlooked achievements of Russian scientists, who did pioneering research on extending human lifespan and explored the effect of living matter on rocks and minerals while building a model of the evolution of the biosphere. As well as showing how Darwin's theory of natural selection could be reconciled with the findings of genetics.

Highlights

- Guided city orientation tour with Andrew, starting with the Arctic and Antarctic Museum which tells the dramatic story of Russia's polar exploration from the 1800s onward.
- Visit the Museum of Cosmonautics and Rocket Technology located on the Peter & Paul Fortress island. It includes rocket engineering items, reconstructed constructor's laboratories, space suits and a landing section of the Soyuz 16 space craft.
- Spend time at the Zoological Museum, exploring the enormous natural history

collection dating back to 1716 when it was started by Peter the Great.

- Enjoy a short drive out of the city to visit the Pulkovo Observatory, built in 1839, destroyed during the Second World War then rebuilt.
- Visit the all-Russian Research Institute of Plant Industry where Vavilov changed the face of agricultural science and genetics.
- Discover the Vasilyevsky Island, the home of the Geological Museum F.N. Chernyshev. The second largest geology museum in the world.
- Travel to town of Pushkin, a former imperial residence and town for the elite. Here you will visit the stunning Catherine Palace, the summer residence of the Russian Tsars.
- Tour the Tsarskoselskaya Amber Workshop, one of the biggest scientific-restoration centres in Europe.
- Explore the State Hermitage Museum. Set over five buildings, it is the second largest art museum in the world and contains everything from prehistoric antiquities to European fine art.

Covid-19 safety protocol includes:

- Pre-departure screening of all guests and tour leaders.
- Increased sanitisation of all accommodation and transport.
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Archaeology

Bringing up the bodies

Mass graves in France have been linked to the Siege of Rennes in 1491

Donna Lu

REMAINS buried in two mass graves in the same cemetery in France have been identified as medieval soldiers belonging to opposing armies.

Rozenn Colleter at the French National Institute for Preventive Archaeological Research and her colleagues have identified the skeletons as belonging to soldiers who fought in the Siege of Rennes in 1491. The skeletons were found buried in a cemetery outside the Jacobin Convent in Rennes.

The researchers identified the skeletons by combining historical information with archaeological techniques, including genetic analysis. They found that each skeleton was male and older than 15, with traumatic injuries including unhealed wounds to the skulls and upper limbs. This pointed to a burial of soldiers.

Radiocarbon dating placed the graves somewhere between the middle of the 15th century and the end of the 16th century. The team believes they contain opposing soldiers from the Siege of Rennes, a major event in the

French-Breton war, which was triggered by a succession dispute.

The war ended with several treaties, and the Breton duchess Anne of Brittany married King Charles VIII of France in 1491, a crucial step towards the formation of the modern state of France.

"It's a really nice use of the archaeological techniques to shine a light on a historic event," says Rachel Wood at the Australian

A large grave in Rennes probably contains soldiers from the French Royal army

National University in Canberra, who wasn't involved in the study.

Using stable isotope analysis of teeth and bones, the researchers were able to determine where the soldiers probably spent their childhood and last years of life.

Carbon and nitrogen isotopes shed clues on people's diet, such as whether they were eating marine or terrestrial foods, says Wood, while strontium isotopes indicate the underlying geology of a region.

Oxygen isotopes can reveal the type of water people drank, which

differs depending on precipitation levels. And one kind of sulphur isotope varies with distance inland. "The ocean has got a particular sulphur isotope concentration, and so if you're by the coast, there's kind of a sea spray effect," says Wood.

Oxygen, strontium and sulphur isotopes from the soldiers in the smaller grave, which contained four skeletons, suggested that they probably grew up in Brittany or returned to the region within the last few years of their life, making it likely they were soldiers allied to Anne of Brittany. In the larger grave, which contained at least 28 skeletons, analysis pointed to origins in the French kingdom, suggesting they were members of the French Royal army (bioRxiv, doi.org/f2m4).

Despite being from opposing armies, the two graves were in close proximity to each other. The researchers note the presence of a rosary and three sets of pearls, pointing to a more careful burial, potentially by Dominican friars, than was afforded to many soldiers during war at the time. ■



COLLETER ET AL.

Astronomy

Alien rocks regularly whip through the solar system

AN AVERAGE of seven interstellar objects pass by the sun every year, potentially close enough for us to observe and even visit, according to a new analysis. Some of these could even be from another galaxy.

To date, two objects from other planetary systems have been found in our solar system: 'Oumuamua in 2017 and the comet Borisov in 2019. We know these objects are interstellar in origin because they

are moving faster than the escape velocity of our solar system.

Stars like our sun are expected to eject trillions of such objects from their star system in their lifetimes. Astronomer Marshall Eubanks at the company Space Initiatives and his colleagues used data on the motion and velocity of nearby stars from the Gaia telescope of the European Space Agency (ESA) to estimate how many of them might end up in our neighbourhood.

They found that an average of 6.9 interstellar objects around the size of 'Oumuamua – at least 100 metres across – should pass within

1 astronomical unit (the Earth-sun distance) of the sun every year.

The researchers estimated this by calculating the expected velocities of interstellar visitors and working out how long they should remain in our solar system. They found that the large majority should travel up to 100 kilometres per second, indicating they originate from the main plane of the Milky Way.

But a small portion – 0.03 per

"A small portion of interstellar objects – three per century – could come from outside our galaxy"

cent, or three objects per century – could have velocities of more than 530 kilometres per second, meaning they originated from outside our galaxy's disc, perhaps even from another galaxy (arxiv.org/abs/2103.03289).

Some of these interstellar objects could be potential targets for remote observations or even visits by future spacecraft, like ESA's Comet Interceptor mission. "We will never in our children's, children's, children's lifetimes send a probe to another galaxy," says Eubanks. "In this case, it might just fall into our lap." ■

Jonathan O'Callaghan

Animal behaviour

Electric catfish can't be stunned and it isn't clear why

Cameron Duke

ELECTRIC catfish can emit up to 300 volts to stun their prey. The fish is immune to its own jolts, and seemingly can't be shocked at all.

Georg Welzel and Stefan Schuster at the University of Bayreuth in Germany explored the degree to which electric catfish (*Malapterurus beniensis*) are insulated from electric shocks.

In one test, in which a goldfish and one of two electric catfish used in the trials shared a tank, they coaxed the catfish into discharging its electricity by gently brushing its tail. In another, they used a commercial electrofishing device to give the entire tank a jolt. In both trials, the goldfish spasmed and contorted its body briefly before recovering, but the catfish was unaffected.

"It was absolutely amazing to see how unexpressed and relaxed electric catfish swam through their tank when being confronted with electric shocks that usually narcotise other fish," says Welzel.

To test whether the catfish's nervous system has the same insulation as its muscles, they added electrodes that maintained a current in the water. They then played a loud blast of sound to startle the fish into emitting a shock. If the animal's nervous system was impaired by the ambient electric field, the fish probably wouldn't react by producing a shock, says Welzel.

High-speed cameras were used to watch for any delay in the fish's reaction, if one occurred. When the sound was played, the catfish reacted normally and emitted a shock, displaying what seems to be a nearly complete immunity to electricity (*Journal of Experimental Biology*, doi.org/f2jt).

The paradox of the electric catfish becomes more mysterious when you consider that catfish often hunt by sensing weak electric fields emitted by their prey – so it isn't as though they lack a way to detect the fields. ■

Geology

One side of Earth's interior is losing more heat

Michael Marshall

OUR planet is a bit lopsided. One half of Earth is losing heat from its interior faster than the other half, and has been for much of the past 400 million years.

The uneven heat loss may be a relic of past supercontinents, when all the land masses were joined together on one side of the planet.

"We see that the Pacific has lost more heat," says Krister Karlén at the University of Oslo in Norway. Karlén and his colleagues reconstructed the rates of heat loss from Earth's interior over the past 400 million years by combining two sources of data.

The first concerns the amount of heat from Earth's interior that flows up through the crust. This data set shows that oceans aren't as good at trapping heat inside Earth as the continents are, says Karlén. That is partly because continental crust is often many kilometres thicker than oceanic crust, so it is a better insulator.

175
million years since Pangaea began to break up

The second data set relates to the movement of the continents deep in prehistory. Some continental rocks carry telltale traces of Earth's magnetic field, which varies around the globe.

Data from these rocks can be used to show that Earth has, on several occasions, been home to a supercontinent – and can help establish some of those supercontinents' approximate positions. The most recent supercontinent was Pangaea, which existed from around



PAUL CAMPBELL/GETTY IMAGES

335 million to 175 million years ago and was centred roughly where Africa lies today.

When Karlén and his colleagues reconstructed the pattern of heat loss over the past 400 million years, they found that more heat had been lost from the Pacific hemisphere of the planet than from the opposite African hemisphere, where Pangaea once lay (*Geophysical Research Letters*, doi.org/fz6s).

The cycle of supercontinent formation and destruction is intimately linked to the heat of Earth's interior, says Louis Moresi at the Australian National University in Canberra. "The supercontinents insulate the Earth," he says, so heat accumulates underneath them.

Moresi says some of that heat escapes on the supercontinent-free side of the planet, creating the hemispheric imbalance that Karlén's team observed. But the heat build-up under supercontinents may also be what destroys them.

"When all the continents come together, they're pushed together by the plates, so they heat up and everything moves faster and it breaks everything

Earth's Pacific side loses more heat than its African side

up," says Moresi.

Other factors may also help explain why the Pacific side loses more heat. At mid-ocean ridges – long chains of volcanically active mountains on the sea floor – magma cools to form new oceanic crust. Crucially, the mid-ocean ridges in the Pacific create new crust faster than those in the Atlantic.

"The fast-spreading ridges produce lots of young oceanic crust that can transport heat out quickly," says Karlén.

The research team also found that rates of heat loss were higher over most of the past 400 million years than they are today. That is because Earth currently has an unusually large amount of old oceanic crust, says Karlén. "Older oceanic crust is thicker and doesn't allow as much heat to escape," he says. This means the present-day situation might not be very representative of Earth's history.

"They're making the case that right now is not typical," says Moresi. "I think that's right." ■

Archaeology

Hunting small game may have driven our evolution

Michael Marshall

OUR ancestors' diets changed dramatically over the course of the past 2.5 million years, and one research team thinks that this shift profoundly affected our evolution.

According to a team including Miki Ben-Dor and Ran Barkai at Tel Aviv University in Israel, hominin diets were once so dominated by meat from massive animals that the hunters caused some of those species to go extinct.

This, in turn, forced our ancestors to develop more sophisticated hunting methods to bring down smaller, more elusive prey, leading to greater intelligence and the evolution of modern humans.

"The key idea is that just one ecological driver drove all of human evolution," says Ben-Dor. "The one driver is the decline in prey size."

Humans – members of the *Homo* genus – appeared roughly 2.8 million years ago, eventually replacing the more ape-like *Australopithecus* hominins that lived in Africa prior to that time.

Ben-Dor and his colleagues compiled evidence on what these early hominins ate. This included traces of foods preserved on teeth, animal bones with cut marks suggesting butchery and chemical analyses of preserved hominin protein.

They concluded that *Australopithecus* ate mostly plants. However, early *Homo* species ate more meat. When our species, *Homo sapiens*, first appeared about 300,000 years ago, meat was still a large dietary component, but within the past 50,000 years, we began eating less (*American Journal of Physical Anthropology*, doi.org/f2mc).

In a second study, published in February, Ben-Dor and Barkai argue that early humans like *Homo erectus* were mostly hunting very large animals like elephants. This, they say, only required simple spears.

"You probably need more courage to hunt an elephant than to hunt a zebra, but it's less complex," says Ben-Dor.

However, he points to a 2019 study that found that the populations of such megafauna were declining in east Africa, beginning 4.5 million years ago. He argues that hunting by hominins contributed to that decrease. As the largest animals became rarer, hominins had to hunt smaller, nimbler animals. That required better technology, such as bows and arrows, and necessitated the evolution of greater intelligence (*Quaternary*, doi.org/fzb9).

It's "an interesting hypothesis", says Sherry Nelson at the University of New Mexico.

Did hunting change our evolutionary trajectory?

Parts of it do fit the evidence, she says. For instance, *Australopithecus* seems to have had big guts, similar to plant-eating gorillas, while there is evidence that early *Homo* species ate more meat.

But Nelson isn't convinced that *H. erectus* was regularly hunting the largest animals.

50,000

Time in years since our species may have begun eating less meat

"Going after big game like that implies a significant level of cooperation and coordination and planning," she says, even if it doesn't need complex tools.

Nelson also questions whether the sequence of events lines up with the hypothesis. Most of the megafauna extinctions happened within the past 25,000 years, well after *H. erectus* itself had become extinct. By 25,000 years ago, our species had long since evolved big brains. "That doesn't really fit," she says. ■



SHUTTERSTOCK/IGOR DENKOFF

Technology

AI can tweak VR videos to stop cybersickness

Matthew Sparkes

WHEN using virtual reality, the discrepancy between what you see and what your inner ear tells you is happening can provoke a form of nausea known as cybersickness. AI that adapts VR scenes to match the motion of the head more accurately can reduce this.

Most VR technology uses three degrees of movement. What you see changes when you tilt, nod or rotate your head. However, it doesn't take into account translational motion – that is, forwards and backwards as when walking, up and down as when crouching or standing up, and side-to-side when sidestepping.

Walk around while watching a 3D video in a VR headset that was filmed from a static point and you may succumb to cybersickness as it won't reflect all your movement. Researchers at UK firm Kagenova have created a system that reacts to these additional degrees of freedom, and a study has shown that it reduces VR-induced nausea.

Kagenova's software uses AI to slightly alter images from 3D videos to take account of movement from one spot to another. The software can adapt existing images so no new technology is required to record footage, and it can work with any VR headset.

To see how well the new approach worked, Elisa Ferrè and her colleagues at Royal Holloway University of London ran tests to compare a standard VR set-up with one using Kagenova's software. The team got 25 people to use HTC Vive headsets to view 3D footage of a beach using both set-ups. The participants reported 33 per cent less nausea when experiencing VR with six degrees of freedom compared with just three (arxiv.org/abs/2103.03898).

Ferrè believes that the benefits would be even larger in a more "compelling visual scenario" that included more movement. ■

Evolution

Electricity helps fish take flight

Genes that govern bioelectric signals in fish also give them wing-like fins

Claire Ainsworth

FLYING fish may have taken to the air when evolution tweaked electrical signals that control the size of their fins. This discovery suggests the existence of a previously unknown mechanism by which animals can change the relative size of specific body parts.

“How organs and tissues know when to stop growing at a certain size and stay there is a major mystery,” says Jake Daane at Northeastern University in Massachusetts. This scaling, known as allometry, is also a key driver of evolutionary change.

The stunning variation in the fins of bony fish are a classic example, from the billowing veils of the tropical betta fish to the stumpy appendages of a mackerel.

Most dramatic of all are the wings of flying fish, which allow some species to leap from the sea and glide for 400 metres, the length of eight Olympic swimming pools. This helps fish evade underwater predators, a tactic so successful that it has evolved independently several times.

In comparisons of the genomes of nine species of flying fish and



ANTHONY PIERCE/ALAMY

Flying fish fins spread like wings, letting them soar for hundreds of metres

some non-flying relatives, Daane and his colleagues spotted genetic changes consistently associated with gliding, and uncovered sections of the genome being conserved by natural selection.

The team also studied mutations affecting fin size in zebrafish, which have short fins suited to streams and ponds. This is unlike flying fish, which have expanded their paired fins – equivalents

of our arms and legs – into wings to take flight.

The zebrafish work revealed two interesting gene variants: one affecting how potassium ions flow into cells, which made all the fins larger; the other affecting how cells absorb compounds called amino acids, which made all the fins smaller. Neither affected the overall body size of the fish.

Similar genes and cellular processes involving them showed up in the flying fish genomes. But this didn't explain why only their paired fins are overgrown.

So the team combined both gene variants in one zebrafish, and found that only the paired fins were overgrown, transforming the zebrafish into a copy of a flying fish (bioRxiv, doi.org/fz6j).

Potassium ion flow affects how electrical charge moves over tissues, which affects embryonic development – including fin growth – and tissue regeneration. But the exact mechanism is poorly understood, and it is unclear how amino acid uptake could tweak bioelectricity to create such specific changes in fin size.

Combining lab genetics with the comparison of genomes is a very creative approach to unpick the mechanisms behind allometry, says Peter Currie at the Australian Regenerative Medicine Institute in Melbourne. Understanding how evolution generates shape and form will aid research into how tissues regenerate, he says. “The more you understand about the evolutionary processes that guide the formation of structures, the more you'll be able to understand and to use in [medicine].” ■

Technology

Robots raise wages for all but increase the gender pay gap

WHEN industries replace workers with robots, wages rise for all on average due to productivity gains, but the difference in pay for men and women widens.

Cevat Giray Aksoy at King's College London and his colleagues analysed the effects of automation in 20 European countries using data from the statistical office of the European Union. They found that the number of robots per

10,000 workers increased, on average, by 47 per cent between 2006 and 2014. On average, a 10 per cent rise in robot workers in a country led to a 1.8 per cent rise in the discrepancy in pay between genders (*European Economic Review*, doi.org/fz6k).

Aksoy and his team say this is because there are more men in medium- and high-skilled jobs, and these roles disproportionately benefit from automation. They say progress in recent decades to reduce the gender pay gap could be quickly eroded by automation. On average, the introduction of minimum wages

reduced the gender pay gap by around 2 per cent, so robots have had a much larger effect.

The widening of the gender pay gap was more pronounced in countries where gender inequality was already high and labour laws provide less support for women in work. In countries where gender inequality was low, automation had no statistically significant effect on the gender pay gap.

“Progress in recent decades to reduce the gender pay gap could be quickly eroded by automation”

“Governments should force companies to be more transparent when it comes to their pay schemes, so we can see where discrepancies are coming from,” says Aksoy. He thinks governments should introduce coding and high-tech skills to school curricula and provide ongoing support for education among adults to help people train for new careers when jobs are lost to automation.

“But at the same time they should make sure that the system and the labour market is fair to everyone,” he says. ■

Matthew Sparkes

Ecology

Some Amazon jaguars spend months in trees

Joshua Rapp Learn



EMILIANO ESTERCI RAMALHO

ONE of the largest predators in the Amazon river basin is learning to live the high life due to seasonal flooding of forests. Jaguars (*Panthera onca*) can spend months on end living and hunting in trees.

"This behaviour is unique because we know that jaguars can swim and jaguars can climb trees. What was surprising to us is that jaguars can remain and survive on top of trees for that amount of time," says Emiliano Ramalho at the Mamirauá Sustainable Development Institute in Brazil.

Ramalho works in the Mamirauá Sustainable Development Reserve, an 11,240-square-kilometre area between the Amazon river and its tributary, the Japurá river, in the north-east of Brazil.

The whole forest becomes seasonally flooded for three to four months every year, and some locals in the region had told Ramalho that jaguars in the area lived in trees for that period. Scientists had never reported jaguars doing this.

Ramalho and his colleagues used trail cameras to watch for this behaviour, as well as briefly capturing jaguars and equipping them with GPS tracking collars to follow them through the region during the high water season to see whether they left

Jaguars in part of the Amazon have a unique way to deal with floods

the completely flooded area when the water level increased by as much as 10 metres. The data showed that the big cats stayed in the trees for the entire flooded season (*Ecology*, doi.org/fz5r).

In this area of the Amazon, jaguars have feeding habits that might help them live this way. While other jaguars mostly prey on medium to large land-based animals, these individuals ambush caimans during the dry season and smaller tree species like howler monkeys and sloths throughout the year.

The cats' small size may also help them live in trees, says Ramalho. In the Mamirauá, jaguars weigh only around 50 kilograms, about half the weight of jaguars in places further south, such as the Pantanal of Brazil.

The study also highlights the diversity of jaguars in the Amazon and the significance of ecosystems like these flooded forests. "It shows how important it is to conserve those completely flooded environments," says Rafael Hoogesteijn at Panthera, a global wild cat conservation organisation. ■

Technology

Fire safety app gives route away from wildfire

Edd Gent

WILDFIRES rampaging through rural communities are becoming a worryingly common sight thanks to climate change. A new mobile app could help guide people who are stuck onto a path to safety by providing simple directions like those given in maps applications.

In recent years, massive wildfires have devastated landscapes and endangered people and animals in the US, Australia and Greece. These disasters have led to scores of deaths, and there is a growing scientific consensus that destructive wildfires will become more frequent as the planet continues to warm.

"It's a very serious problem," says Andreas Kamilaris at the CYENS Center of Excellence in Cyprus. "The statistics show that casualties, as well as the area of land burned, around the world are increasing year by year."

That prompted Kamilaris and his colleagues to build a mobile app that provides personalised evacuation routes to anyone caught in the path of a wildfire. The app connects over mobile

The app then takes the GPS location of each user to work out potential routes, selecting the best by weighing up how quickly each route gets them to safety against how close it takes them to the fire's path.

The best option is then displayed either as turn-by-turn directions or as a route overlaid on a map of the area similar to those used by popular maps apps.

In a small pilot at the Athalassa National Forest Park in Cyprus, all 17 people who took part successfully escaped a simulated fire. In questionnaires they answered after the trial, the participants said the app was easy to use and that they would use it in a real wildfire (arxiv.org/abs/2102.11558).

But Ed Galea, a fire safety expert at the University of Greenwich in the UK, worries that the route-planning algorithm in the study is too simple to deal with the complexities of a real-world evacuation, such as varying travel speeds or potential congestion on escape routes.

And while fire and evacuation models can help experts plan or respond to emergencies, he thinks even state-of-the-art systems have limitations that currently make them unsafe in the hands of untrained people.

"That is not to say that the goal of having a personalised wildfire evacuation guidance system is not achievable," he says. "Just not today."

Kamilaris admits the app still needs work and says the researchers plan to add features, like the ability to tailor travel speed and monitor users to prevent congestion, before testing again in more challenging scenarios. ■

15

Number of minutes between new predictions of fire spread

networks to a web server running a fire simulation program, which uses publicly available data on geography, weather and vegetation type to predict the spread of fires at 15-minute intervals.

A fire management tool similar to those already in use lets local fire departments quickly tag when and where a fire starts, which is then used to generate real-time simulations.

Passport tool fails with dark skin

The UK is still using a racially biased photo checker despite an update being available

Adam Vaughan

THE UK government has failed to deploy an updated version of an “effectively racist” face analysis algorithm used for checking passport pictures, despite knowing it works poorly for some black people. The improved version has been available for more than a year.

New Scientist revealed in 2019 that the Home Office had deployed a face-detection system for its passport photo-checking service despite being aware it worked badly with very light and very dark skin.

The passport office said in February 2020 it had talked to the software’s vendor, which had amended the tool, and it could be deployed after testing by the vendor and the Home Office.

However, more than a year on, the passport office confirmed it has still not applied the fix, leaving individuals from some ethnic minorities facing obstacles to an essential service.

“Her Majesty’s Passport Office can confirm that we have not deployed the updated software,” the agency told *New Scientist* this

month in response to a freedom of information request.

Since the service went live in June 2016, some black users of the service have reported being told their photo didn’t meet requirements after it mistook lips for an open mouth and suggested people had their eyes closed when they were open. The passport office said in October 2019 that

A passport checker used in the UK performs badly on some skin tones



VIOLETASTOMENOVA/GETTY IMAGES

it was working to make the experience of uploading a digital photograph simple “for all of our customers”.

Noel Sharkey at the University of Sheffield, UK, says the issue was shocking 18 months ago, but seems even worse now it has persisted for so long. “What I find most alarming is that the software company produced a solution more than a year ago and it has not been used. It leaves open the question as to why the Home Office is still using this effectively racist algorithm.”

New Scientist understands the covid-19 pandemic has affected work on updating the software.

Such bias in algorithms can be introduced if they are trained on an insufficiently diverse set of data.

“Software tends to fail for minority groups because the people developing it, and the people incentivising and authorising it in turn, do not take the needs of those groups seriously,” says Os Keyes at the University of Washington, Seattle. “Why has the patch to treat people

of colour as people not been applied? Because the Home Office doesn’t prioritise [people of colour].”

Sam Smith of campaign group MedConfidential, who unearthed documents showing that the UK government knew about the software’s problems before deployment, says: “Every day the Home Office doesn’t use the improved software is another

“The software company produced a solution more than a year ago and it has not been used”

day that the Home Office actively chooses to run a service for British citizens which discriminates based solely on the colour of their skin.”

A Home Office spokesperson says: “We are determined to make the experience of uploading a digital photograph as simple as possible, and continue to work hard with our supplier to identify ways to improve this process for all of our customers.” ■

Technology

A quantum trick with photons gives AI a speed boost

MACHINE learning, a process used to train artificial intelligence, can take an extremely long time – but a quantum trick could massively speed things up for tasks involving particles of light called photons.

In reinforcement learning, an algorithm runs through the same problem over and over again and is given a numerical reward only when it reaches the correct answer. That process teaches it to find the correct

answer more quickly when pitted against similar problems later on.

Now Valeria Saggio at the University of Vienna in Austria and her colleagues have added a quantum twist to accelerate this process. They set up an experiment involving a photon moving through a wave guide and ending up in one of four possible states. They tasked an AI with making sure the photon ended up in one particular state, and rewarded it for doing so.

In the classical version of this experiment, without any added quantum effects, the AI would only be able to move the photon to one

specific state at a time, being rewarded when it made a correct guess. However, in the quantum version of the experiment, the AI could put the photon in a superposition of more than one state. This allowed it to narrow down the correct answer before making a final, classical guess at the goal state (*Nature*, doi.org/fz3v).

“Imagine you have a robot that is standing at a crossroads, and the

“The quantum version would allow the robot to go simultaneously left and right at each guess”

robot has two options – it can go left or it can go right,” says Saggio. “If the robot goes right, it does not receive a reward, but if it goes left it receives a reward. At the next round, the probability of it going left will increase.”

That’s the classical version of the experiment, but the quantum version would allow it to go left and right simultaneously at each guess, requiring far fewer guesses before it learns to always go left. This strategy sped up the learning time of the AI by 63 per cent, from 270 guesses to just 100. ■

Leah Crane

Materials

Wooden floors can generate power as you walk on them

FUNGI could help us transform wood into a material that can generate electricity if people just step on it.

The possibility of applying pressure to wood to produce an electric charge, known as the piezoelectric effect, has been long discussed. However, the vanishingly small amount of electricity it produces has held back the idea.

Now, a team led by Ingo Burgert at ETH Zurich, Switzerland, has discovered how to tweak balsa wood to make its piezoelectric output 55 times higher. The solution was to rot the wood.

Burgert and his team applied a white rot fungus (*Ganoderma applanatum* - pictured) to balsa for several weeks. This decayed the lignin and hemicellulose within the wood, reducing its weight by almost

half. They found the sweet spot was six weeks of treatment to create wood that was more compressible. This meant it generated more electricity when pressure was applied, but didn't lose its strength.

The team then rigged up blocks of the decayed wood, covered with a veneer, to create a prototype "energy floor" that was wired up to an LED. The amount of electricity generated is still small – 0.85 volts from one cube of decayed wood 15 millimetres across (*Science Advances*, doi.org/fz5x).

Initially, this could power remote sensors, for example ones that detect whether an older person has fallen over, suggests Burgert. However, in the longer run he envisages energy floors such as a wooden ballroom producing a much greater output. **Adam Vaughan**



DUNCAN USHER/ALAMY

Anthropology

Truth about ancient massacre uncovered

THE remains of a group of people massacred 6200 years ago have been analysed to reveal their ages, sex and ancestry.

Mario Novak at the Institute for Anthropological Research in Zagreb, Croatia, and his team retrieved DNA from 38 of 41 individuals found in a mass grave in Potočani, Croatia. The other three sets of remains contained insufficient material to sequence. The DNA, along with an analysis of the skeletons, helped the team learn more about those killed.

There were at least 41 people of both sexes and almost all age groups – the youngest was about 2 years old and the oldest about 50. Radiocarbon dating of each individual and layers of the mass grave indicate that they were killed and buried in 4200 BC.

The researchers found that the burial site contained 21 males and

20 females. Half of them were under 17 years old at time of death. They saw evidence of head injuries on 13 skulls, probably caused by blunt weapons. "We assume that these people were probably kneeling or lying down and were struck from behind," says Novak.

The research also revealed that just 11 of the genetically analysed individuals were linked by family ties. All 38 genetic samples showed a similar ancestral mix of 91 per cent of DNA from Anatolian Neolithic people and 9 per cent from western European hunter-gatherers (*PLoS One*, doi.org/fz59).

"This massacre was not orientated to a very specific part of the community or of a particular family," says Novak. The people in this group were killed indiscriminately as there were members of both sexes, all age groups and several families – as opposed to other examples of massacres in prehistoric communities in the Copper Age. **Karina Shah**

Health

AI can assess pain of sickle cell disease

AN ALGORITHM can determine the pain that someone with sickle cell disease is experiencing by using just their vital signs. Doing this could ensure people get the most suitable pain management.

As pain is subjective, it is hard to measure in a standardised way. Daniel Abrams at Northwestern University in Illinois and his team set out to see if physiological data that is already routinely taken,

including body temperature, heart rate and blood pressure, could be used to devise a system that assesses pain levels in a more objective manner.

They used data from 46 adults and children with sickle cell disease, which affects the shape of blood cells (pictured). They used physiological data and patient-reported pain scores to develop models that could deduce pain levels and detect changes in pain level through machine learning.

The researchers then compared their new artificial intelligence models with existing ones that try to assess pain levels, but without physiological measurements. The new models outperformed the existing ones (*PLoS Computational Biology*, doi.org/fz53).

This could be especially useful for children, says Abrams, because they often struggle to explain the level of pain they are experiencing.

The team believes that this method can be extended to other causes of pain. **Krista Charles**



MARK GARLICK/SCIENCE PHOTO LIBRARY



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Really brief

ALDOMURILLO/GETTY IMAGES



More twins being born now than ever

The global rate of twin births has risen, according to data from 165 countries. It shows there were 9 twin births per 1000 births in the 1980s, but 12 per 1000 today. Fertility treatment may be a factor as the hormones used to promote production of eggs can see two released at once (*Human Reproduction*, doi.org/fz5s).

Covid-19 stimulus plans bad for nature

Schemes designed to boost economies in the wake of the pandemic will make conservation harder. An analysis of plans found 64 examples of environmental rollbacks, such as allowing oil drilling in protected areas (*The International Journal of Protected Areas and Conservation*, doi.org/fz5v).

Sponge could soak up oil in Arctic spills

An artificial sponge can suck up 99 per cent of oil from colder water, offering a solution to oil spills in the Arctic. Cold oil crystallises and grows thicker and stickier, but the sponge uses a coating that mimics the structure of the thicker oil to mop it up (*Science Advances*, doi.org/fz5w).

Physics

Gravity of really tiny object measured

WE HAVE measured the pull of gravity exerted by the smallest object yet tested – a 90-milligram gold sphere. This could help us understand how gravity fits together with quantum mechanics on the smallest scales.

We know our understanding of gravity isn't complete. It doesn't explain how dark energy speeds up the expansion of the universe, nor does it fit with quantum mechanics, which describes

how objects behave on very small scales. One way to try to fit the pieces together is to observe how small objects interact with gravity.

Markus Aspelmeyer at the University of Vienna in Austria and his colleagues have taken this to the smallest extreme yet. They used a specialised pendulum to measure the gravitational field of a tiny gold sphere with a radius of about 1 millimetre.

They wiggled the gold sphere back and forth by 1.6 millimetres while it was near a similar gold sphere attached to the pendulum. The gravity of the first sphere

moved the second one by just a few nanometres, which then swung the pendulum.

This allowed them to calculate the gravitational field of the first sphere, the least massive object whose gravity has been measured.

To measure these tiny effects, the apparatus had to be extremely sensitive. The researchers shielded it from electromagnetic forces using a Faraday cage and did the experiment in the middle of the night during the least seismically active time of year – around Christmas – in a vacuum (*Nature*, doi.org/fz6h). **Leah Crane**

Archaeology



J.A. SOLDEVILLA/UNIVERSITAT AUTÒNOMA DE BARCELONA

Women may have ruled over ancient European civilisation

A BRONZE Age society could have been ruled by women, at least some of the time. Archaeologists have found the bones of a woman buried with a silver crown and other riches under a building that seems to have been used for political meetings.

She lived in a society dubbed El Argar – the name of the first archaeological site preserving evidence of the culture, excavated in the 1880s. The culture dominated what is now south-east Spain from around 2200 BC to 1550 BC.

Roberto Risch at the Autonomous University of Barcelona in Spain and his colleagues have been excavating an Argaric site called La Almoloya

for several years. The ancient building they found seems to have had some kind of governmental purpose, perhaps serving as a palace or a form of parliament.

Buried in a very large jar under the floor, the team found the bodies of a woman and a man. Both had a multitude of funerary goods (pictured), suggesting they were eminent in Argaric society. Most of the items, including the most spectacular ones, were found on the woman. She was wearing a silver crown, silver earplug piercings and silver bracelets. As a result, the team believes she was the ruler (*Antiquity*, doi.org/fz5q). **Michael Marshall**

Technology

Sensor warns you if you're sitting too still

A SMALL sensor worn on the neck containing origami-like folded wires can monitor how much we move while sedentary, and tell people to get up and exercise.

Musculoskeletal disorders like neck pain are a major issue, reflecting the way we increasingly work sitting down. Moving often can prevent problems.

Zhengbao Yang at City University of Hong Kong and his team developed small, stretchable sensors that are powered by piezoelectricity – charge that is generated through squeezing or stressing suitable materials.

The sensor monitors the movement of the neck and is powered by layers of piezoelectric material folded in a structure from kirigami, which is related to the art of origami or paper folding.

When the wearer moves, the sensor deforms and sends charge to a microcontroller that registers movement with an accuracy of 95 per cent. If the wearer doesn't move their neck or shoulders more than 10 times in every half hour, a prompt is displayed on their computer (*Science Advances*, doi.org/f2jh).

Yang is hopeful the sensor can make the leap from lab to real life soon. **Chris Stokel-Walker**

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The columnist

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A stunning bird-shaped murmuration of starlings **p28**

Culture

The explosive story of SpaceX’s early days **p30**

Culture columnist

Rowan Hooper on Kazuo Ishiguro’s latest novel **p32**

Comment

Protect the pollinators

Pollinators have a critical, but largely unappreciated, role to play when it comes to climate change, says **Jeff Ollerton**

YOU would be forgiven for not knowing that there are two large United Nations environmental events happening this year. The UN Climate Change Conference (COP 26) in Glasgow, UK, is receiving a huge amount of media attention; the UN Biodiversity Conference (COP 15) in Kunming, China, much less so. At least, outside *New Scientist*.

This is a source of frustration to us ecologists, but it is fairly typical: the climate emergency often overshadows the ecological emergency, even though the two overlap both in their causes and their solutions.

Although ceasing the extraction of fossil fuels is a priority, if we are going to reverse the effects of climate change we need nature-based solutions, built on conservation of biodiversity, to capture the carbon dioxide from the atmosphere. Pollinators are crucial to this, but their numbers are declining, some species have gone extinct and others are critically endangered.

Around 75 per cent of the world’s main types of crops rely on pollinators. Without them, our diets and farmers would be poorer. But their value in combating climate change is often overlooked. Almost 90 per cent of the 352,000 species of flowering plants are pollinated by insects and vertebrates such as birds and bats. As such, pollinators ensure the continuation of plant populations that lock up carbon in their woody stems, roots, bulbs and tubers.



The best way to restore natural habitats to help fight global warming is through natural regeneration from seeds, and for that we need pollinators.

But this may not be the most important role of pollinators in relation to climate change; how they affect soils may be more critical. When a pollinator visits a flower it sets in motion a chain of events that leads not just to seeds, but also to a series of structures that support plant reproduction. These include woody fruit casings that protect the developing embryo, as well as dispersal structures such as the wings

of sycamore seeds. All of these contain a very high proportion of carbon. Once they have fulfilled their function, they fall to the ground where they enter the soil as a source of locked-in carbon.

Soils are the world’s second-most important carbon store, and much more important than the vegetation that they support. In fact, three-quarters of terrestrial carbon accumulates in soils. Only the oceans contain more carbon by mass.

How much carbon enters the soil thanks to the activities of pollinators? We have no idea as it hasn’t been measured. Ecologists

studying forest carbon dynamics use fine nets strung between stakes to measure the “litter” that falls from trees each year. The contribution of reproductive litter, as opposed to leaves or twigs, isn’t always calculated, but when it is values of 10 to 20 per cent of the total litter are typical, depending on the type of plant.

We have limited understanding of what happens when this material enters the soil. A large number of seeds are stored in the soil and they can be persistent, and reproductive litter can be very woody compared with leaves, and thus their carbon storage capacity may be greater.

For these reasons, it is vital that we pay more attention to international agreements, such as the Convention on Biological Diversity, and enact policies that safeguard pollinators, for example by banning harmful pesticides and creating larger protected areas. This requires action now at all levels, from governments to conservation groups, to create and restore habitats in which pollinators can thrive.

Drawing down carbon from the atmosphere and sequestering it requires multiple approaches; there is no single solution. Without pollinators as allies, reversing the effects of climate change will be much harder. ■



Jeff Ollerton is at the University of Northampton and author of *Pollinators & Pollination: Nature and society*

This changes everything

Who wants to be an animated gif millionaire? Non-fungible tokens are an amazing tool for digital art, but it is hard to tell how much of it is just a financial stunt, writes **Annalee Newitz**



Annalee Newitz is a science journalist and author. Their latest novel is *The Future of Another Timeline* and they are the co-host of the Hugo-nominated podcast *Our Opinions Are Correct*. You can follow them @annaleen and their website is techsploitation.com

Annalee's week

What I'm reading

Sociologist Kim TallBear's fascinating analysis of science and race in Native American DNA.

What I'm watching

It's a Sin, Russell T. Davies's amazing recreation of queer life in London during the 1980s and 90s.

What I'm working on

Researching the history of adventure stories about the American West.

This column appears monthly. Up next week: James Wong

LAST month, somebody bought a 10-year-old animated gif of a flying cat for over half a million dollars. It isn't some symptom of pandemic panic, nor is it a new scam. Instead, it is all thanks to a tiny piece of code called a non-fungible token, or NFT, that offers an internet solution to a very internet kind of problem.

The problem is that art gains its value from being unique, but when you can download anything online, suddenly art doesn't seem so valuable. The solution is the NFT, a unique digital token associated with an image or video file that can't be copied. The NFT is stored on a blockchain – a secure, decentralised digital ledger – just like bitcoins are. Presto! A unique piece of “crypto art” that is worth something.

NFTs have made headlines because creators are selling their crypto art for enormous amounts of money. In mid-February, digital artist Chris Torres sold his 10-year-old meme creation, Nyan Cat, for about \$580,000. For those who don't recall it, Nyan Cat is a gif of a cartoon kitty with the body of a toaster pastry, who runs endlessly to the beat of a Japanese pop song while trailing a sparkly rainbow across a twinkling night sky. Torres remastered the 2011 gif and sold it on crypto art auction site Foundation.app.

Anyone can own a copy of the Nyan Cat gif – just as anyone can own prints of a Frieda Kahlo self-portrait – but only one person can have the official gif, identified by its unique NFT. This has been a boon for digital artists, who are finally able to market their work in the way more traditional artists do. On Foundation, you can peruse digital art that runs the gamut from genuinely gorgeous to disturbing or obviously silly.

Some are static images, but most are gifs of some kind.

It is hard to explain why the best of these looped videos are mesmerising, just as nobody can fully account for why Nyan Cat was one of the most-watched things on YouTube in 2011. But we all know a good gif when we see it, and for people who have grown up online, that is worth something. If a popular creator is involved, that makes it even more valuable. Musician Grimes auctioned off a collection of crypto art in early

“We all know a good gif when we see it, and for people who have grown up online, that is worth something”

March – a few short, sci-fi-themed videos set to original music – and earned almost \$6 million.

None of this is being sold for actual dollars or pounds, of course. It is all in cryptocurrencies like bitcoin. Most creators prefer to deal in a cryptocurrency called ethereum, in part because its blockchain offers support for contracts that define how a piece of content can be used.

But NFTs aren't merely for art snobs. Canadian firm Dapper Labs quickly discovered that basketball fans would pony up thousands of dollars to collect little bursts of video called “Top Shots”, showing awesome plays from several angles. The National Basketball Association teamed up with Dapper Labs to launch a special Top Shots store. There, fans can buy and sell Top Shots with cryptocurrency, and show off their collections. According to CryptoSlam, which monitors NFT markets, Top Shots are the most heavily traded collectibles.

One of the other top-selling collectibles is a digital hipster version of Beanie Babies called CryptoPunks. Created by two artists who run New York-based Larva Labs, CryptoPunks are unique “characters” – 8-bit cartoon heads with slightly different hair, facial expressions, hats and skin colour – that people collect and trade using ethereum. It sounds bonkers until you consider how much money people pay for digital objects inside their favourite games. Or for *Magic: The Gathering* cards. We like to collect things, regardless of whether they are made of bits or atoms.

Looked at from one angle, crypto art promises to do what great art has always done: turn an ephemeral moment into something enduring, something that can be owned. This seems especially needed on the internet, where creative content is often treated as expendable trash precisely because it is so easy to make copies.

At the same time, many of the big NFT sales feel like capitalist stunts, a new flavour of the get-rich-quick schemes associated with cryptocurrencies. Like crypto coins, NFTs have to be “mined” using mathematical calculations that are resource-intensive, slurping up energy to power servers that quickly turn into piles of electronic waste. Some artists may be making money, but our CryptoPunk and Top Shots habits are terrible for the planet.

There is also a basic question about whether we need blockchain technology to recreate the experience of collecting unique art. As author Robin Sloan pointed out, after experimenting with selling tokenised amulets bearing tiny poems, the whole thing might be better handled by using a simple spreadsheet. ■



Parental guidance

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Catherine
de Lange

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Wild Wild Life



Editor's pick

More worries about the risk of disease spillover

Leader, 6 March

From Roger Myers, London, UK

Your leader and the associated feature "Spillover" (p 41) appear to lay the blame for the pandemic primarily on our destruction of biodiversity and encroachment on fragile ecosystems. Yet for most of human evolutionary history, people have lived within such ecosystems in small groups as hunter-gathers and would surely have been just as exposed to zoonotic infections.

The difference then was that these tribes were mostly isolated from one another, with only occasional contact. In contrast, almost all human groups are now deeply interconnected. This factor was arguably just as important in making the pandemic possible.

While preventing the destruction of nature is vital, doing things like figuring out how to quickly break the chains of transmission across the interlinked global human population should also be made a priority. After all, the next pandemic might not spawn from zoonotic sources, but something more malign like bioterrorism.

From Fiona Tomley and Dirk Pfeiffer, GCRF One Health Poultry Hub, Hatfield, Hertfordshire, UK

We agree with your article on the problem of pathogens spilling over from animals to humans as we encroach on nature. There is another big factor influencing zoonotic disease emergence, though: the intensification of food animal production.

Escalating demand for animal protein means the density of livestock systems is increasingly high. Consequences include pollution, monoculture (for animal fodder), poor animal welfare, high pathogen growth and genetic adaptation. Moreover, to compensate for poor husbandry and biosecurity, more than half of antimicrobials used on the planet are in food animal production,

adding to the "silent" pandemic of antimicrobial resistance.

It has been known for years that highly intensive systems increase the risk of food-borne disease and spillover of zoonoses with pandemic potential, such as avian flu. The SARS-CoV-2 pandemic has raised awareness, but we must recognise the interaction between components in eco-social systems that generate zoonotic disease risks. In that context, future development of food animal production is a major priority.

Could non-viral factors look like long covid?

27 February, p 10

From Laura Alexander, Dollar, Clackmannanshire, UK

While it is possible that the symptoms described in your look at long covid in children are due to this syndrome, they could also be caused by a lack of social contact and education, limited opportunities for exercise and sunshine exposure, constantly hearing apocalyptic news reports, being cared for by stressed adults, being forced to spend long periods looking at screens and so on.

Extended mask wearing will hamper the recovery

6 March, p 10

From Bryan Simmons, Bratton, Wiltshire, UK

Those of us who wear glasses can suffer badly from lenses steaming up while wearing a face mask. It is a nuisance when doing something necessary like shopping. Given the talk of masks being required until 2022, I certainly wouldn't pay to go to a concert, the theatre or a museum if I could only see a blur. So, when these places reopen, many of us wouldn't want to go if masks are still mandatory.



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Reduce and reuse is the only plastic bottle remedy

6 March, p 23

From Shenali Kalawana, London, UK

You reported research that found 2.3-litre plastic bottles are the least harmful to the planet. But why advocate an optimum size at all? We shouldn't create loopholes for the production of harmful plastic products. The best way to prevent harm is to reduce use of plastic bottles and switch to reuse and refill business models.

Why do we think about time as two dimensional?

6 March, p 46

From Martin Jenkins, London, UK

I read Julian Barbour's article on the possibility of time flowing backwards with great interest, as I have recently been wrestling with the same questions (from the point of view of philosophy rather than physics).

However, it raised questions that weren't addressed. If time, like space, is expanding from the big bang, shouldn't it also be expanding in all directions, not just forwards and backwards? What are the implications of a universe in which time is expanding sideways? Is the forwards/backwards concept of expanding time the result of our linear experience of time and our inability to think in other terms?

For some, exercise is the key to keeping weight off

27 February, p 32

From Guy Cox, St Albans, New South Wales, Australia

My own experience differs from some of the claims in Herman Pontzer's article on human metabolism, particularly the lack

of weight loss caused by exercise.

In my teens, I took up running. When my children were of school age, I had less time to run and I really put on weight – about 25 kilograms. Once school duties were out of the way, I started running again – about 5 to 10 kilometres at least five times a week – and my weight went right back down. Then I injured my knee. It was operated on, but I am now unable to run and that 25 kilograms returned. I know many people like me who have to exercise or they will put on weight.

Alien cryptocurrency may need a mega power source

30 January, p 44

From Dave Smith,

Alnwick, Northumberland, UK

I have been wracking my brains to think of something requiring the amount of power provided by a Dyson sphere. On considering recent news articles, however, the answer finally dawned on me: an alien mega civilisation that has based its entire monetary system on a bitcoin-like blockchain.

Spin a yarn in the battle against garden slugs

27 February, p 49

From Mike Starke,

Chale Green, Isle of Wight, UK

Here is a tip for Clare Wilson to keep the slugs at bay. My wife grows crop after crop of pristine green beans. Her secret is to pack pieces of hand-spun fleece yarn around the bean stems. This has successfully deterred the gastropods from adding her *Phaseolus vulgaris* to their diet. ■

For the record

■ In our report on life found underground (27 February, p 14), we should have said the deepest previously known life was microscopic nematode worms.

■ It is the sun's increasing energy that will warm Earth in the far future (6 March, p 12).

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A fabulous beast



Photographer James Crombie

THIS extraordinary image, taken as dusk approaches, looks like a soaring bird from a fantasy film. In reality, it is a murmuration – a huge swarm of starlings moving and pulsating as a single spectacular mass in the sky.

Murmurations can comprise up to hundreds of thousands of flying starlings, though few are quite as dramatic as this one. Photojournalist James Crombie captured it over Lough Ennell, a lake near Mullingar in Ireland, after more than 50 visits in which he took hundreds of shots.

Starlings are thought to form murmurations to protect themselves from predators, such as peregrine falcons, since it is much harder to single out an individual among such large numbers.

The birds can coordinate themselves because they respond so quickly to their neighbours. No single starling leads the swarm. Instead, each individual reacts as its neighbour changes direction or speed. We now know that starlings do this in groups of around seven: the movements of each small unit rapidly scale up to the entire murmuration, resulting in the shape-shifting masses.

How the birds manage to avoid collisions is still a bit of a mystery, but one idea suggests that when certain starlings initiate a turn, the decision spreads through the rest of the murmuration like a wave. ■

Gege Li

SpaceX's explosive start

On paper, Elon Musk's audacious start-up should never have succeeded. It very nearly didn't, as **Paul Marks** discovers in the story of SpaceX's early days



Book

Liftoff: Elon Musk and the desperate early days that launched SpaceX

Eric Berger

William Collins

IN THE autumn of 2008, a Falcon 1 rocket built by a maverick start-up called SpaceX lifted off from Kwajalein Atoll in the North Pacific Ocean and made it all the way to Earth orbit. After three earlier attempts had failed, it meant Elon Musk's 6-year-old firm suddenly moved from being a mere wannabe to a space-flight player to be reckoned with.

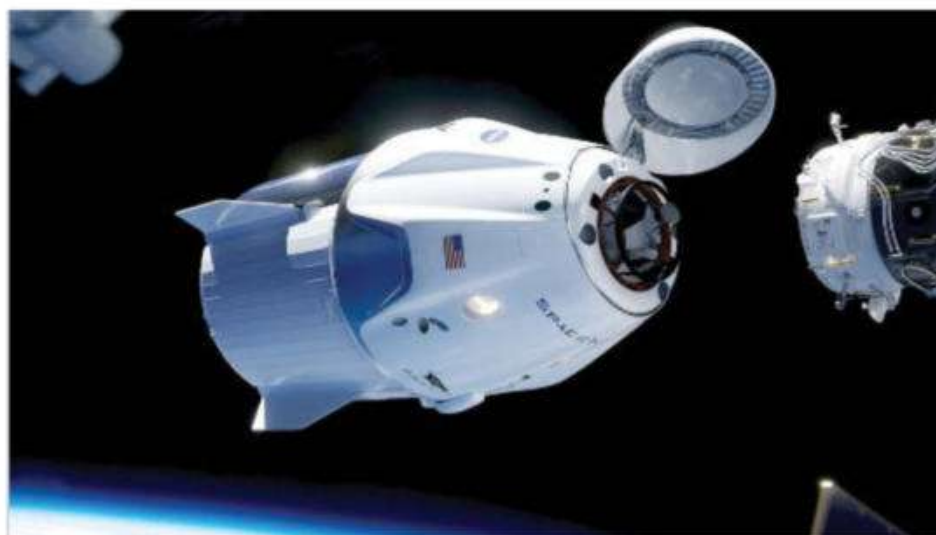
But it had been a close run thing. In *Lift Off*, Eric Berger's compelling history of SpaceX's early days, we discover what few knew at the time: if that fourth flight of the Falcon 1 had also failed, the company could easily have gone bust.

It was vital that the rocket reached orbit because it was powered by SpaceX's home-grown, ultra-efficient kerosene/oxygen Merlin rocket motor. Nine of these would be needed for the much larger rocket that cash-rich clients like NASA wanted to use to send cargo to the International Space Station (ISS) – and, later, crewed missions. If Falcon 1 hadn't shown that the motor could power a rocket to orbit, there might not have been a Falcon 9, the rocket that has become the backbone of SpaceX's business.

Berger chronicles the amazing human and technological struggles that led to the success of the launch. To be convincing, he needed unprecedented access to Musk and, perhaps more crucially, to the key propulsion, avionics, structural and launch engineers behind Falcon 1.



SPACEFLIGHT/SHUTTERSTOCK



DCPHOTO/ALAMY

SpaceX's Starship rocket exploding (top) and Crew Dragon in space (bottom)

After tracking them all down, Berger captured their entertaining warts-and-all stories of potentially avoidable foul-ups, the details of which make this book an essential, unofficial reference text for what to do (and not do) as space flight goes commercial.

What drives SpaceX, Berger writes, is Musk's relentless quest to get humans to Mars as soon as possible. That means two things: a laser-like focus on hiring the

smartest engineers, and adopting ultra-fast engineering techniques.

Musk comes across as a fiercely demanding boss, and the lengths he goes to hand-pick talent are revealing. On one occasion, he called Google co-founder Larry Page to ask if a senior Google staffer could work from a Los Angeles office instead of a Silicon Valley one so that the staffer's spouse could work for SpaceX. Page agreed. When an academic found that five of his 10 students had gone to work at SpaceX, Musk is said to have got in touch – not to explain, but to find out where the other five went.

Engineering rockets faster, however, means eschewing traditional aerospace processes in which design engineers can spend careers “creating stacks of paperwork without ever touching hardware”, says Berger. Musk's approach involves testing systems

“At the time of writing, three prototypes of the firm's Starship Mars rocket have exploded spectacularly”

early, designing out flaws so each version becomes more reliable.

It also means not being afraid to fail – and fail SpaceX has. From running out of liquid oxygen on the launchpad – which boiled off, as it took too long to fix software-related shutdown bugs on the launchpad – to fuel lines leaking due to salt corrosion in the tropical air of Kwajalein, the company has experienced a litany of errors.

But SpaceX has gone on to shake up the industry by cutting the cost of launching satellites threefold, developing a staggering ability to land rocket stages that its competitors still ditch, as well as flying astronauts to the ISS from US soil on its Crew Dragon for the first time since the space shuttle retired.

The firm's army of online fans seems to be getting used to its “go fast, break things and fix them” process. Attempts to land Falcon 9 rocket stages failed many times before success dawned. At the time of writing, three prototypes of the firm's Starship moon and Mars rocket have exploded spectacularly. All of which makes it a particularly good time to publish *Liftoff*, the fascinating backstory of why SpaceX does it this way. ■

Paul Marks is a London-based writer specialising in space and technology

Drugs and the dark web

Silk Road fictionalises a bid to create an online narcotics empire, but it isn't clear where its sympathies lie, says **Linda Marric**



Film

Silk Road

Tiller Russell

Vertigo Releasing,
streaming from 22 March

IN OCTOBER 2013, Ross Ulbricht was arrested by the FBI and charged with money laundering, conspiracy to commit computer hacking and conspiracy to traffic narcotics. Two years earlier, Ulbricht had launched the Silk Road, the first modern dark web market, known for selling drugs that are illegal in the US.

Suddenly, users could order any illicit substance they wanted from dealers online and have it delivered, no questions asked, to their homes by the US Postal Service the very next day.

Ulbricht's site operated as a Tor hidden service, making it easier for its users to browse it anonymously and conduct all their transactions using untraceable cryptocurrencies. Within a few months, Ross had amassed a huge following under the pseudonym Dread Pirate Roberts (a reference to *The Princess Bride* movie) and a small fortune in bitcoin thanks to an article about the site, which appeared in the now defunct Gawker blog.

But what was the route that took a twentysomething, middle-class physics graduate from Texas to the FBI's most-wanted list?

In *Silk Road*, the movie version of the story, writer-director Tiller Russell (whose catalogue includes *Night Stalker: The hunt for a serial killer*, a four-part exploration of the crimes of Richard Ramirez) maps out Ulbricht's trajectory from law-abiding citizen to drug player in this flawed crime story. It is based

on "Dead End On Silk Road: Internet crime kingpin Ross Ulbricht's big fall", a *Rolling Stone* article written about Ulbricht by David Kushner.

The film opens at a branch of the San Francisco Public Library in 2013, where Ulbricht (Nick Robinson) is being trailed by undercover federal agents hoping to catch him red-handed logging onto his site. Then it flashes back to a couple of years before that, to a Texas bar where gaudy libertarian show-off Ulbricht is attempting to smooth-talk his way out of an awkward political exchange with Julia (Alexandra Shipp).

Soon the two become inseparable, and when he jokingly suggests launching a website from which dealers can easily sell drugs, both Julia and Ulbricht's best friend Max (Daniel David Stewart) are happy to go along with his wild scheme.

Although we are cheekily warned from the start that "this story is true. Except for what we made up or changed", there are clearly some aspects of the tale that are simply there to pad out an otherwise stale

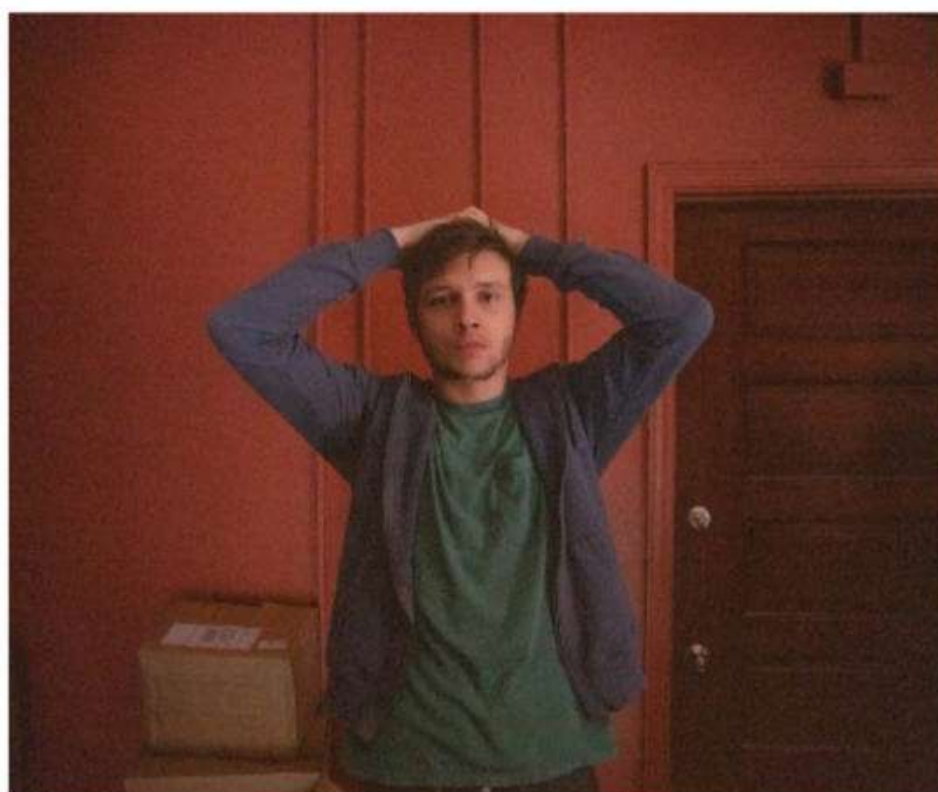
and meandering screenplay.

For example, a subplot featuring a brilliant turn from Jason Clarke (*Zero Dark Thirty*) as crooked cybercrime agent Rick Bowden often feels superfluous.

Robinson gives a suitably nervy and understated performance as the anti-hero you wish you could root for. It is this moral ambiguity that gives the film the edge it needed, but it is a shame that more isn't made of this by Russell. Elsewhere, Paul Walter Hauser (*I, Tonya* and *Richard Jewell*) gives another scene-stealing turn as hapless Utah hacker Curtis Clark Green, Ulbricht's employee.

Overall, *Silk Road* often seems unsure where its sympathies lie, and this is its main problem. Having said that, there is just enough here to keep those who are unfamiliar with the story hooked till the bitter end. Just don't go expecting anything as good or full of cracking dialogue as David Fincher's *The Social Network* or you will be sorely disappointed. ■

Linda Marric is a film writer based in the UK



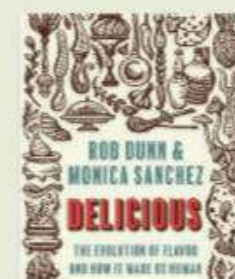
Nick Robinson as Ross Ulbricht, founder of the dark web marketplace Silk Road

Don't miss



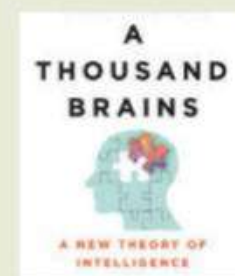
Watch

Invincible, available from 26 March on Amazon Prime Video, animates Robert Kirkman's long-running comic about an ordinary teenager whose father just happens to be Omni-Man, the world's most powerful superhero.



Watch

Rob Dunn, co-author of the new book *Delicious* with Monica Sanchez, speaks about the deep history of flavour and the role it has played in human evolution. Online from the Royal Institution in London at 7 pm GMT on 23 March.



Read

A Thousand Brains: A new theory of intelligence by Jeff Hawkins, inventor and neuroscientist, explains how the brain builds not just one model, but hundreds of thousands of models of everything we know.

The sci-fi column

Getting along with a robot The latest book from Nobel prizewinner Kazuo Ishiguro is a fascinating tale about artificial intelligence, friendship and what it means to be human, says **Rowan Hooper**



Rowan Hooper is podcast editor at New Scientist. His latest book is *How to Spend a Trillion Dollars*



ANNA GORIN/GETTY IMAGES

Klara and the Sun is about a solar-powered “artificial friend”

what this novel seems to be dealing with, is the growing atomisation of society and the decay of empathy between people.

Klara’s outlook reminds me of Haley Joel Osment’s character in the 2001 film *A.I. Artificial Intelligence*, directed by Steven Spielberg. Osment plays a robot boy programmed to be capable of love. Klara is designed to be a friend, and when she is selected by Josie, her function simply becomes that of “friend to Josie”. Klara’s own desires are only hinted at. She is a conscious being, but her artificiality means she is treated differently – and discriminated against – by humans.

Klara is a complex and interesting protagonist. She has great insight and empathy – a bit like the book’s author, who won the 2017 Nobel prize for literature, in fact – but I think Ishiguro wants to suggest that humans will never recognise these traits in an artificial creature because of our prejudice for the biological. That might be true, though I hope that if we do ever create a human-level AI, we will treat it respectfully, as a sentient life form.

The other sci-fi that the book reminds me of is the rebooted *Battlestar Galactica*. In this series, cybernetic creatures called Cylons are originally created from the minds of humans uploaded into digital form. It doesn’t really work out well for either entity. In the end of this novel, Ishiguro seems to say that humans and human-level AI will never get along, and that there is some insoluble mystery about human nature. Sadly, he might be right about the first point; I am not sure he is about the second. ■



Book

Klara and the Sun
Kazuo Ishiguro
Faber & Faber

Rowan also recommends...

Books

House of Suns
Alastair Reynolds

Set 6 million years in the future, this galaxy-spanning epic concerns human spacefarers and a fascinating variety of artificially conscious beings.

Autonomous
Annalee Newitz

A brilliant look at robot-human relations in the near future and the issue of ownership and indenture, as well as the blurring of lines between organic and inorganic intelligence. See their latest column on page 24.

AS SOON as I started reading Kazuo Ishiguro’s new novel, *Klara and the Sun*, I fell into the warm and familiar embrace of his writing. As in *Never Let Me Go*, his 2005 novel about human clones raised as organ donors for their original bodies, Ishiguro creates a sort of nostalgic dystopia. He lays a blanket of melancholy over a recognisable but slightly off-kilter world. His style is one of retro science fiction comprising an old-fashioned sensibility and a chilling technology from the future. In *Never Let Me Go*, Ishiguro was worried about cloning; in *Klara and the Sun*, it is artificial intelligence.

The novel is narrated by Klara, who, it soon becomes apparent, is a solar-powered robot. A highly sophisticated, intelligent and self-aware robot, to be sure, but a robot nonetheless. She looks humanish, but she wouldn’t fool anyone into thinking she was actually one of us. I am sure she would pass the Turing test, in that she can demonstrate human-level intelligence, but that isn’t the same as saying that she could be mistaken for human, both in manner and looks.

We meet Klara when she is on sale in the window display of an android shop. We are in a version of our modern world, one where everyone is still glued to smartphones – Klara sees people looking at their “oblongs”, a word surely deliberately chosen for its retro feel – but it is also one where computer and robotic technology

“I hope that if we do ever create a human-level AI, we will treat it respectfully, as a sentient life form”

is far superior to ours. Klara escapes from the store when she is purchased for a girl called Josie.

Klara is to be Josie’s AF, her artificial friend. Humans are so lonely and unable to form attachments to their own kind – and unwilling to listen to the worries and concerns of other people – that they need AFs to fill in for them. It is very Ishiguro. I said that he was worried about artificial intelligence, but what he is really concerned about, and

Planet Boost is an initiative from *New Scientist* highlighting charitable organisations working to conserve biodiversity and protect the natural environment. Today, a message from **Royal Botanic Garden Edinburgh**



Royal
Botanic Garden
Edinburgh



Time for healing the planet and people

The last 12 months have brought heightened awareness of the interdependencies between the health of the environment and the well-being of humans, and there is better understanding of the need for urgency in tackling the global biodiversity crisis and climate emergency. The challenges are great but the possibilities are immense.

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In the Arabian Peninsula, we are working

closely with national governments, contributing data and advice for conservation planning. Where the dry forests of Latin America are rapidly disappearing through large-scale conversion to agriculture, our work has quantified the high levels of endemism and evolutionary uniqueness of these forests and has been fundamental in identifying conservation sites and plans.

As part of an alliance in Sarawak on Borneo, we are documenting the rich plant diversity in wildlife sanctuaries, national parks and nature reserves to facilitate evidence-based sustainable management plans and help build and enhance capabilities and skills in research and conservation management. With Tanzania's forests threatened by rapidly rising demand for wood for construction, fuel and unregulated raw

timber exports, we are modelling the spread of logging and quantifying associated losses of biodiversity, carbon and revenues.

In Scotland, we have developed a web-based toolkit to explore options for woodland biodiversity management, offsetting the risks of climate change and tree disease. This is being trialled to help conserve Scotland's internationally important temperate rainforest. Our plant health programme aims to develop strategies to minimise impacts from emerging pests and pathogens. We have active translocation programmes on bryophytes and lichens and threatened higher plant species, such as the alpine sow-thistle (*Cicerbita alpina*). All our programmes are accompanied by detailed long-term monitoring and stringent plant-health procedures.

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We can make real change but it takes combined determination and resources. Our mission is to explore, conserve and explain the world of plants for a better future. There are many ways to support RBGE. Find out at rbge.org.uk/support-us

GREEN AND ETHICAL checklist

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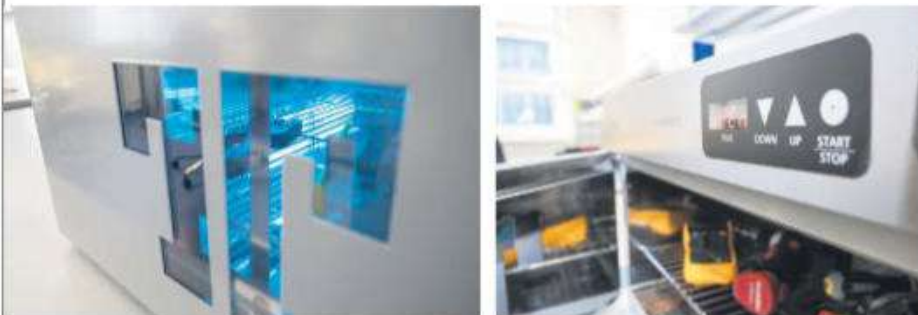


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*Source: Can culinary and medicinal mushrooms help? by Sabaratnam V et al.

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Don't act your age!

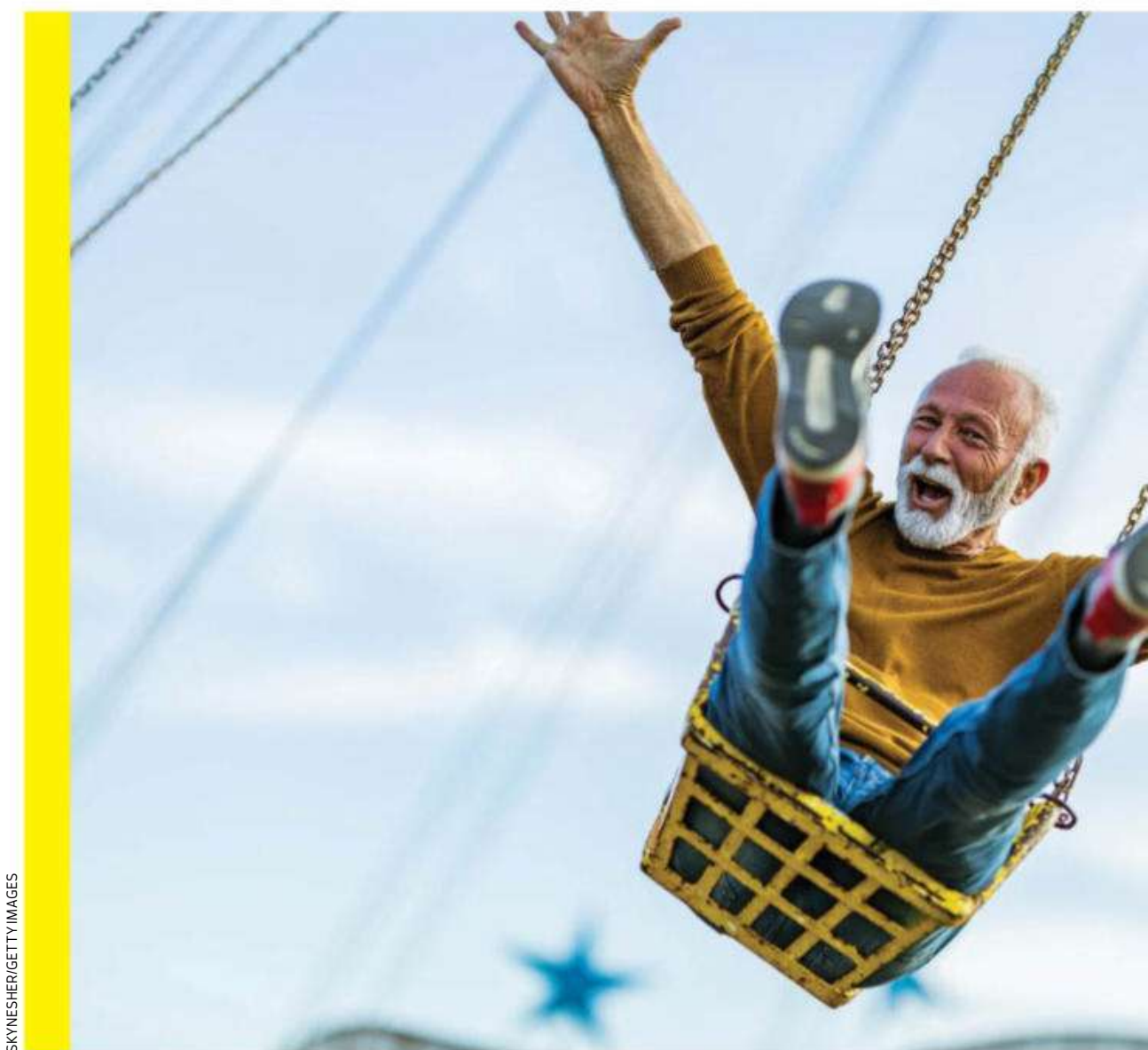
You're only as old as you feel, the saying goes. But it turns out the fountain of youth really is a state of mind, says **Graham Lawton**

AGE is an issue of mind over matter. If you don't mind, it doesn't matter." This nugget of wisdom, often attributed to Mark Twain, has been turned into many an inspirational internet meme over the years. As a 51-year-old who is starting to feel the gathering momentum of the inevitable slide, it strikes me as little more than a platitude that makes people feel better about getting old.

But according to a growing body of research, there is more to it than that. Subjective age – how old we feel – has a very real impact on health and longevity. People who feel younger than their years often actually are, in terms of how long they have left to live.

The question of what controls our subjective age, and whether we can change it, has always been tricky to address scientifically. Now, research is revealing some surprising answers. The good news is that many of the factors that help determine how old we feel are things that we can control to add years to our lives – and life to our years.

We have known for a while now that simply counting the number of years someone has been alive isn't necessarily the most accurate way of gauging longevity. Biological "ageing clocks" measure various markers in the body to see how far along the physical ageing process we are (see "Old bones?", page 38). But we also know that physical ageing is not the be-all and end-all. Gerontologists recognise that just as we can make generalisations about the ways that physical ageing affects our bodies – a 60-year-old will almost certainly show more signs of physical decline than a 30-year-old –



SKYNESHER/GETTY IMAGES

People who feel younger than their years tend to live longer



“A lower subjective age is associated with better health and well-being”

there are some predictable psychological changes that come with age, too.

In the late 1990s, Laura Carstensen, a gerontologist at Stanford University in California, measured how human psychology typically changes as we age. Her work has shown that young people, for whom time seems unlimited, are motivated to pursue knowledge about the physical and social world – to explore and make new connections. As a result, they tend to be more enthusiastic, outward-looking and sociable than their parents and grandparents, but also more superficial, impulsive and emotionally fragile.

Older people, meanwhile, feeling that they have fewer years left to play with, turn away from exploring and concentrate on finding meaning, emotional intimacy and sharing the wisdom of their years.

Just a feeling?

Even within this general psychological trajectory, however, subjective age varies considerably. This isn't terribly surprising: we all know people who are young at heart and young fogeys who think and behave older than their years. Intriguingly, though, studies suggest that being young at heart is seriously good for you. A lower subjective age is correlated with better health, longevity and general well-being, while people with a greater subjective age have higher levels of inflammation, a marker of general ill health, and older-looking brains.

A 2018 paper by Antonio Terracciano at

Florida State University and his colleagues, looked at data from three studies following more than 17,000 people for up to 20 years. They confirmed that subjective age isn't just a feeling, but also a pretty accurate predictor of health. “People who feel younger live longer. Those who feel older have a shorter lifespan,” he says.

So you can get a rough idea of your longevity by figuring out your subjective age. The trouble is that it's not as simple as asking people how old they feel, says Maria Mitina, a biologist at Hong Kong-based biotech company Deep Longevity who is working on the problem. Subjective age can fluctuate widely depending on mood and circumstances, so people's answers may not reflect how old they feel most of the time.

Each of us has a “baseline” that we consistently return to and which may or may not match up with our age in years or our position on the psychological timeline, says Mitina. In this respect, subjective age is like another important quality-of-life measurement, happiness. People's self-reported happiness levels vary greatly from day to day and even hour to hour, but an individual's happiness tends to fluctuate around a characteristic baseline. Somebody who is temperamentally cheerful can have bad days, but will always gravitate back towards this happy medium.

Because of short-term fluctuations in subjective age, simply asking someone “How old do you feel?” isn't a particularly reliable guide to their baseline subjective age. “It is ➤

Old bones?

There are various ways of measuring our progress along the pathway from cradle to grave. The most obvious is chronological age, which is simply how many calendar years we have on the clock.

A more accurate measure, however, is biological age. This treats ageing as a malleable, but fairly predictable, process of biological decrepitude, and uses various biomarkers – such as metabolism and genetics – to assess how far we are through it. There is also immunological age, which measures how youthful our immune systems are.

These “ageing clocks” spit out a number in years that is an estimate of where we stand in relation to an average human ageing at an average rate. It can be higher or lower than our chronological age, sometimes by more than a decade. And, crucially, it can go down as well as up, due to lifestyle changes such as exercising more or drinking less. Age really is just a number – but not necessarily the number of candles on your birthday cake.

Being sociable and open to new experiences can keep you young at heart

not a constant variable: maybe today you feel happier and younger, but in two weeks, you are unhappy and your subjective age will change,” says Mitina.

How to sort a baseline subjective age from all the fluctuations? Alex Zhavoronkov, founder of Deep Longevity and a researcher at the Buck Institute for Research on Aging in California, wondered if artificial intelligence could help. He had already used AI to discover new markers of biological ageing. According to Zhavoronkov, such biological clocks are one of the most important recent advances in ageing research. However, up to now the psychological side has been overlooked.

The chief benefit of using AI is that it can spot patterns in large data sets that aren’t discernible to humans, allowing it to link subjective age to factors that appear to have little to do with it. The data set Zhavoronkov, Mitina and their colleagues chose came from a project called MIDUS (Midlife in the United States). This was a research programme spanning 20 years run by the US National Institute on Aging, which was designed to understand how behavioural, psychological and social factors influence health and well-being with age. The hope was that AI would allow the team to develop a psychological ageing clock like the biological one.

For MIDUS, thousands of people in the US aged 25 to 75 were interviewed, with the same 7100 individuals – dropouts and deaths aside – taking part in the 1990s, 2000s and 2010s. An extra 3500 volunteers were added in the mid 2010s. Each time, volunteers were asked more than 1000 questions about all aspects of their lives, including their physical and mental health, well-being, personality, beliefs, social lives and sex lives. Some questions, such as

DEEPOP BY PLAINPICTURE/LLPH



“How old do you feel most of the time?” and “If you could be any age, what would it be?”, were directly aimed at measuring subjective age. Others quizzed them on less obviously age-related aspects of their physical and mental health, beliefs, personality and lifestyle choices.

Ageing clocks

The first step for Zhavoronkov and his colleagues was to design AIs to comb through MIDUS questionnaires and then train them to accurately predict each individual’s chronological and subjective age from their answers.

After training them on more than 10,000 questionnaires, the researchers say they have cracked it. “We developed two psychological ageing clocks,” says Mitina. The first converts an individual’s answers into



“Positive attitude is more strongly associated with long life than any biomarker”

Feeling young in a time of covid-19

Given that feeling young requires both adventure and socialising, you might think that the lockdowns and social distancing of the covid-19 pandemic are making us all - young and less so - feel ancient.

Antonio Terracciano, a gerontologist at Florida State University, thought so too, but when he did some research, he found

the exact opposite. Most of the 3738 US adults he surveyed reported feeling younger in March and April 2020 than they had in January and February, before the virus took off in the US. “It’s counter-intuitive, but this is what we find,” he says.

One possibility is that feeling younger made people feel less

vulnerable in the face of a disease that was seen primarily as a threat to older people. This is already thought to be a factor in subjective age, says Terracciano. “It is a reflection of psychological distancing from a societal negative stereotype of ageing as associated with disease and death,” he says.

an accurate estimate of their chronological age, providing further evidence that people’s psychology really does follow a predictable pattern as they get older.

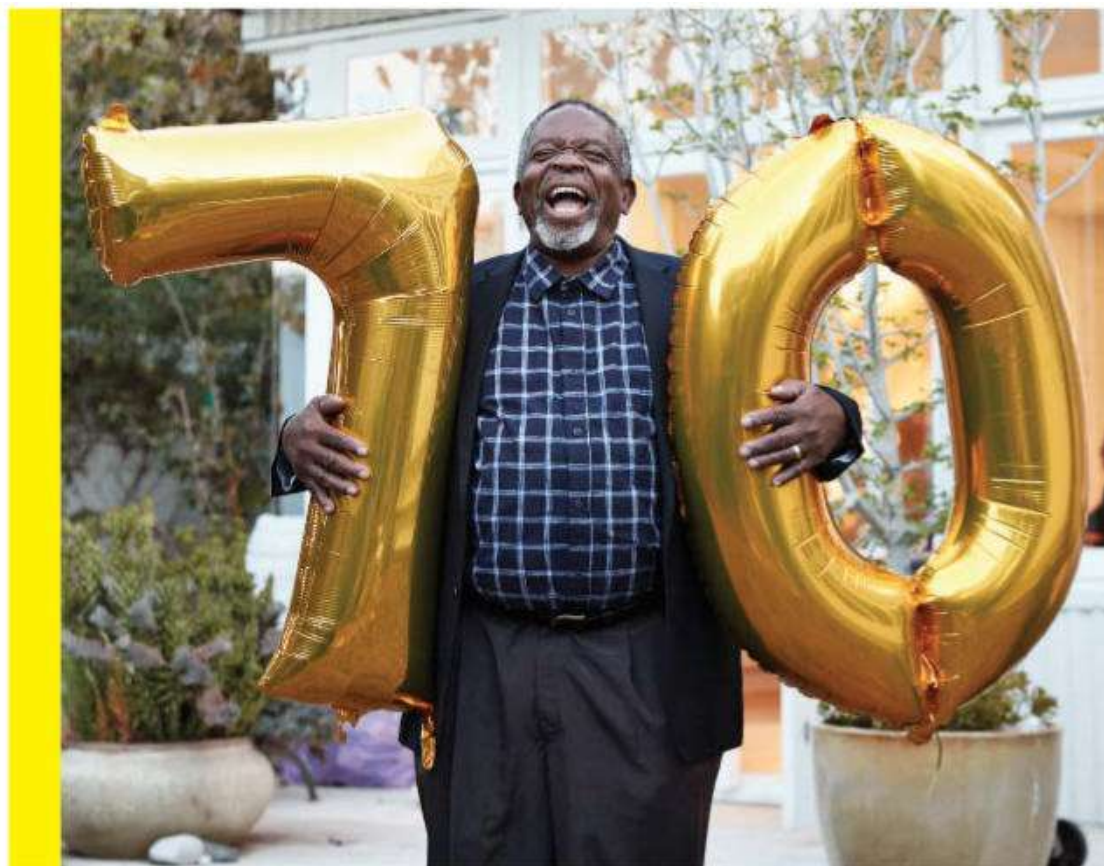
The second, which they called SubjAge, spat out an estimate of how old people perceived themselves to be based on their answers to questions that didn’t directly ask them about subjective age. These estimates could then be checked against MIDUS questions that were designed to get an estimate of subjective age, such as: “Imagine you could be any age; what age would you like to be?”

The team then validated both models against the MIDUS answers of a further 2500 people and found that both were accurate to within seven years. That is about par for the course in ageing clock research and is good enough to be medically useful, says Mitina, but it could be better. The best biological clocks are accurate to within two years. She and her colleagues are working on adding a biomarker found in blood that they think could tighten up the estimate.

Already, though, the researchers reckon their model is good enough to allow them to identify behavioural and lifestyle factors that were both predictive of subjective age and, crucially, modifiable.

Perhaps unsurprisingly, by far the biggest influence on SubjAge is physical health. Two of the top three predictive questions are: “Does your health limit your ability to do vigorous physical exercise such as running or heavy lifting?” and “Are you taking prescription medication to manage your blood pressure?”

Less predictably, perhaps, the second-most influential factor in people’s SubjAge is how satisfying they expect their sex life to be in 10 years’ time. The effort they put into their ➤



Age is a number – but not necessarily the number of years since you were born

current sex life is also in the top 10 (as the saucy joke version of the old saying goes, you are only as old as the person you feel).

Other contributions to SubjAge aren't obviously connected to youth at all. One of the top 25, for example, is how much people feel they contribute to the well-being of others.

Ultimately, says Mitina, the goal is to turn these findings into lifestyle advice to help people feel more youthful and even live longer. The analysis showed that a 60-year-old with a SubjAge of 65, for example, is twice as likely as a 60-year-old with a matching SubjAge to die from any cause at any given age thereafter.

The magnitude of the effect is surprisingly large, says Mitina. "I think this is the most powerful outcome from our experiment – that higher subjective age doubles mortality risk."

As for the kinds of lifestyle changes to make, the fact that the biggest influence on how old we feel is physical health could give people concrete actions they can take to get their SubjAge down, such as exercise to improve fitness and dietary changes to improve blood pressure.

Going out to explore could also pay

dividends. Several questions probe a person's attitude towards ageing as well as their relationships, community involvement and personality. In all cases, being more open and optimistic helped. People who felt positive about ageing and who rated themselves as extroverts had a lower SubjAge, for instance. "We can ask people to be more open – to new people, new knowledge or new experiences. Push people to be more sociable," says Mitina.

Older, wiser, sexier

This chimes with research on centenarians showing that one thing they have in common is an optimistic and gregarious nature. Positive attitude is much more strongly correlated with long life than any biomarker, according to Kaare Christensen, who runs the Danish Aging Research Center at the University of Southern Denmark.

Others may want to focus their energies closer to home. "It looks like if you are very happy about your sexual life, then you are psychologically younger, so investment in closer relationships can make you younger

"If you are very happy with your sexual life then you are psychologically younger"

and improve well-being," says Mitina.

If answering 1000 questions to find out your subjective age feels like a poor use of time you won't get back, the good news is that you don't have to. Mitina and her colleagues have whittled the questionnaire down to just 15 questions, none of which ask directly how old you feel, and created a website where anybody can get a rough and ready estimate of their subjective age (see app.young.ai/psychoage). I did it and discovered that – depressingly – I feel exactly as old as I am right now.

I am 51; I feel 51; my subjective age is 51. I am putting this finding down to lockdown-induced restrictions on social contact and exercise. On the plus side, if living to a ripe old age requires more friendship, better sex, new experiences and a healthier attitude to ageing, count me in. 40, here I come! ■



Graham Lawton is a staff writer at *New Scientist*

Cloud control

Aircraft create a web of contrail clouds that warms our planet a surprisingly large amount. Can we banish this fluffy menace for good?

David Hambling investigates

THERE are few more delightful antidotes to stress than to lie on your back in warm grass and watch the clouds go by. As children, we love finding the outlines of animals and castles in the billowing shapes. As adults, there is something calming and comforting about those fluffy tufts of white drifting slowly past. Clouds are beautiful. Clouds are innocent.

With one exception. The streaky smears of cloud that criss-cross the sky in the wake of aeroplanes may look too wispy to cause any harm. But we now know that these condensation trails, or contrails, make an outsized contribution to global warming by trapping heat like a downy jacket. "They are one of the few manifestations of man-made climate change agents that you can actually observe," says David Lee, an atmospheric scientist at Manchester Metropolitan University in the UK. As the evidence mounts to show how harmful contrails are, some engineers are reaching for an audacious

solution: scrub them from the sky altogether.

Contrails are created when water condenses to form ice crystals around tiny particles of soot from aircraft exhausts. Yet there is no fundamental reason why this has to happen. Decades of experiments with spy planes, alternative engines and, most recently, with artificial intelligence have shown that it is possible to stop them forming. It won't be easy: wiping the atmosphere clean of contrails may require nothing less than a wholesale reimagining of the traffic in our skies.

The effect of clouds on our climate is subtle because they can both reflect incoming sunlight, which has a cooling effect, and trap heat beneath them, which has a warming effect. However, contrails are a type of artificial cirrus – a thin, cold, high-altitude cloud – and we have known for a long time that these are a climate menace. Their wispiess means they let almost all sunlight through while also trapping heat below them highly effectively.

For sure, cirrus clouds are a natural part of ➤

GEORGE PACHANTOURIS/GETTY IMAGES



“One study found that 57 per cent of the warming caused by aviation was due to contrails”

our skies. But aeroplanes are creating an increasing number of them and recent evidence has laid bare how damaging this is. One study conducted by Lee looked at the atmospheric warming caused by aviation between 2000 and 2018. It found that contrails cause significantly more warming than the carbon dioxide pollution produced by burning jet fuel: 57 per cent of warming was due to contrails and only 34 per cent was from CO₂. The other 9 per cent was down to other components of exhaust fumes. That may come as an unwelcome surprise to climate conscious travellers paying to offset the carbon emissions from their flights because such offsets overlook the impact of contrails.

Admittedly, comparisons between CO₂ emissions and contrails are fraught. This is because the greenhouse gas can stay in the atmosphere for hundreds of years, whereas contrails hang around for a maximum of about 12 hours. Still, contrails are a massive and growing problem. The rise and rise of air traffic may have been stalled by the covid-19 pandemic, with air passenger numbers falling from 4.5 billion in 2019 to 1.8 billion in 2020. But assuming some sort of return to normality

in air travel, passenger numbers could easily begin to increase again – and perhaps very rapidly once the pandemic is under control.

So how do we curb contrails? One method might be to have planes fly at high altitudes. The density of contrails depends on how moist air is, and humidity declines with altitude as the air thins. If aeroplanes were to fly at 18,000 metres, the cruising height of Concorde, there wouldn't be enough moisture for contrails. However, a plane like the Boeing 777 cruises efficiently at about 10,000 metres and just isn't built to fly significantly higher. In any case, atmospheric scientists don't know enough about how exhaust pollutants such as nitrogen oxides would affect the atmosphere when released at such high altitudes. If they were to damage the ozone layer, which absorbs harmful ultraviolet radiation from sunlight, that might outweigh the benefits of contrail control.

Rear-view mirror

Perhaps we can learn a lesson from a time when contrails were a concern for a reason other than climate. In the 1950s in the US, the CIA was preparing for the high-altitude U-2 spy plane to fly over the Soviet Union. It was capable of flying much higher than Concorde, but didn't do so all the time. A visible contrail would be easy for Russian interceptor jets to home in on. There was, it turned out, a way to avoid that risk.

Although humidity tends to decrease with increased altitude overall, there are layers of air throughout the atmosphere with higher and lower humidity thanks to local weather conditions. This meant that adjusting the U-2's altitude by a few hundred metres would usually stop the formation of contrails, or “conning” to use the aviation slang. The only trouble was that pilots often couldn't tell when they were leaving a trail. In the end, the CIA found a simple fix: fitting a rear-view mirror outside the U-2's cockpit. That way, pilots could see their own trails and try switching altitude.

This low-tech solution wouldn't be practical in the maelstrom of modern air traffic. And with contrails back in the



Contrails were a potentially disastrous giveaway of the position of the U-2 spy plane



Contrails look innocent but cause considerable global warming

spotlight for environmental reasons, the hunt is on for a better fix.

Aircraft engines are an obvious place to look. Today, most planes use jet engines known as single annular combustors that have one ring of burners. Double annular combustors, a less common sort of engine, have two rings and so burn fuel more completely, producing little soot. “The number of ice crystals is pretty much dependent on the number of soot particles,” says Marc Stettler at Imperial College London’s Transport and Environment Laboratory. “If we were to reduce them, that would reduce the contrail.” Stettler recently analysed methods of reducing contrails and found that fleet-wide adoption of double burning engines would cut the climate impact of contrails by more than 60 per cent.

Switching the engines of the world’s airliners is too expensive to be feasible in the short term. However, there is one idea that might provide a quicker fix. It involves a return to the

CIA’s method of shifting altitudes so that planes fly in layers of air with low humidity – but this time guided by something a little more sophisticated than a rear-view mirror.

The idea is to use real-time atmospheric models to pinpoint in advance low-humidity layers of the atmosphere where contrails won’t form, then divert planes accordingly. Making such predictions is a huge challenge. But Adam Durant, the founder of SATAVIA, a company based in Cambridge, UK, says his firm can do it. SATAVIA has developed a planet-wide model of the atmosphere up to an altitude of 18,000 metres fed with detailed meteorological data and processed by AI. “We’re now able to run our complex atmospheric models in hyper-resolution and at global scale for the first time,” says Durant.

In principle, this would make it possible to route flights so that they form fewer contrails. If it can be done, there is evidence to suggest the effects will be important.

In the same study that examined engine changes, Stettler looked at a set of flights over Japan and found that a tiny number of them – which he calls “big hits” – accounted for the vast majority of the warming caused by contrails. The flights responsible tended to produce contrails that hung around for a long time. If these flights, accounting for just 2 per cent of traffic, were diverted so that they didn’t produce contrails, the warming effect on the climate would again be reduced by 60 per cent. Emirates airline, based in the UAE, has agreed to work with SATAVIA to test the idea in the coming months.

Fasten seat belts

It isn’t a perfect fix. Greg Thompson at SATAVIA points out that diverting planes to lower altitudes can increase fuel burn, while pushing them higher increases the risk of turbulence. “Do I ask passengers to wear seat belts due to possible turbulence in order that we avoid producing a contrail?” he asks.

Klaus Gierens at the German Aerospace Centre Institute for Atmospheric Physics near Munich has cast doubt on whether the strategy will be effective. He recently compared two methods of predicting contrails with real weather data and contrail observations. The results suggested that predicting where contrails will form is possible, but it is much harder to predict which will be long lasting – Stettler’s “big hits” – and it is these that do the damage. Gierens didn’t test the method used by SATAVIA, however; the full details haven’t been made public. The firm remains confident that it has cracked it.

The history books might record 2021 as the beginning of the end of contrails. But their demise is going to take a while. Until then, when we look up on a clear day, we will see a wispy reminder that the planet is slowly and steadily getting warmer. ■



David Hambling is a technology journalist based in London

The climate financier

Former central banker **Mark Carney** has turned his attention to the economics of the climate crisis. Solving it means realigning the values of financial markets with the values of society, he tells Richard Webb

MARK CARNEY made his name as a sound steward of money. He entered the public eye in 2008 when he was appointed governor of the Bank of Canada at the age of just 42, and his swift and decisive interventions there are credited with helping the country weather the storm of the global financial crisis better than any other rich nation. From 2011 to 2018, he was chair of the global Financial Stability Board, established in the wake of that crisis to strengthen oversight of the world's banks and try to avoid a repeat. In 2013, Carney was appointed governor of the Bank of England, the first non-Briton to oversee the UK's central bank since it was established in 1694.

Since stepping down from the governorship in 2020, he has turned his focus to the tricky interface of economics and the environment. He has returned to the private sector as a vice chair and head of impact investing at Canada-

based firm Brookfield Asset Management – a role that recently garnered some controversy for that firm's definition of its net-zero climate investments. Carney is also the UN special envoy for climate action and the finance advisor for the UK government's presidency of the UN's COP26 climate change conference, a crucial point for the world's climate plans, scheduled to take place this November in Glasgow. He has just written a book called *Value(s): Building a better world for all* about how we can and must rework capitalism to help solve the crises we face.

Richard Webb: What is the significance of your book's title, and what was it that motivated you to write it?

Mark Carney: I came in as governor of the Bank of Canada at the start of the global financial crisis. I finished as the governor of the Bank of England literally the week of the first UK

lockdown, at the start of the covid-19 crisis. Throughout that time, a third crisis – the climate crisis – has been building too. I reflected on all this and realised that, in many respects, these are all crises of values – in particular the relationship between how markets value things versus the broader values of society, including values that are necessary, actually, for the market to work well. The book tries to chart a way of thinking about value in economic terms and philosophical terms. It looks at how that thinking has changed, how that's contributed to these crises and then what responses will work.

How has our perception of value changed?

Mark Carney: Markets have come to the narrow view that only things that can be given a price have value. We can price Amazon, the company – its current market value is almost \$1.7 trillion – but value is only ascribed to the Amazon, the



ROCIO MONTÓYA

region, when the ecosystem is destroyed for the purposes of agriculture or harvesting timber. Meanwhile, the market view of value applies not only to material goods, but increasingly to the whole of life, from the allocation of healthcare to education and environmental protection. The seeds of the crises we have experienced lie here.

The belief in unfettered markets has become central to Western capitalism in recent decades. Is that era over?

I think we have seen the dangers of it. The global financial crisis, which was caused in part by surrendering supervisory judgement to the perceived wisdom of the market, showed that danger. But we need the dynamism that market value brings from innovators and entrepreneurs to develop solutions to the problems we face. We need to get market value and societal values back into an equilibrium.

"We can price Amazon, the company. But value is only ascribed to the Amazon when it is destroyed"

What do the financial, covid-19 and climate crises tell us about how market value and broader societal values have diverged?

One thing it tells us is about how markets undervalue resilience. It has become clear from covid-19 that we underinvested in basic pandemic preparedness. The cost of putting in place at least the initial provisions to protect our healthcare workers, to protect vulnerable people, to have mass testing, would have been equivalent to the economic output we lost in a single day during the crisis. That's nothing, yet those investments weren't made. In the climate crisis, similarly, we've undervalued the resilience of ecosystems.

Then there is the value of solidarity. In the run-up to the financial crisis, individuals in financial institutions were increasingly focused on their own pay and little on the risks they were running for their organisations, and still less for the wider financial system. There ➤

wasn't a sense of being part of a bigger set of entities or of custodianship.

By contrast, we've seen a very positive sense of solidarity in the covid-19 crisis. Early on, a million people volunteered to support the NHS in the UK. The vast majority of people have observed lockdown restrictions – through concern for their own health, yes, but also the health of others. Having recognised that greater value needs to be placed on resilience, on solidarity and crucially on sustainability, we need to talk about what sustainable growth is and what needs to happen to achieve that.

Does inequality need to be part of the conversation too?

The pandemic shone a light on the inequalities in our society. The burden of the disease and its economic impact have fallen disproportionately on particular groups, for example racial groups. These inequalities have been widened by the covid-19 crisis, and yet we're all facing the same enemy, if you will. The question is: what do we do about that?

We also have issues around inequality of

"It's early stages, but markets are developing mechanisms that put a price on nature"

economic opportunity related to the digital revolution, which in many respects has been accelerated by this crisis. Many tech companies talk about a world that is "digital by default"; in other words, working will become more distributed, remote and digital. That has many advantages if managed properly. But letting technological innovation run its course without directing it to broader human needs can be risky.

In what sense risky?

Previous industrial revolutions have tended to widen inequality. Increases in wages for workers lag behind productivity increases, generally by decades. We need to ask whether machine learning, artificial intelligence and so on enhances people's jobs or diminishes them. There's a difference between digital by default and digital by design.

What does "digital by design" look like?

It means ensuring the benefits of new technologies are shared, in the sense of as many people as possible being able to participate. Are we, for example, changing our social welfare systems, our educational systems, our tax systems and our financial systems to keep pace with new ways of working, to provide adequate support and opportunities for lifelong retraining?

New financial technologies have a part to play here. For instance, machine-learning algorithms can more easily and rapidly make judgements about which start-ups deserve financing and can grow quickly. That can help close what in the UK is about a £20 billion financing gap for smaller companies. Similarly, technology can dramatically reduce the cost of cross-border payments, opening up a much bigger global marketplace for smaller companies – say, someone selling fashion.

My point is that, if we're conscious about it, we can build an architecture where you have a kind of artisanal globalisation that spreads activity in a way that not only creates jobs, but promotes good jobs and reduces inequalities, both between regions and between individuals.



An AI-driven car undergoing tests in China. There is a risk that new technologies don't benefit us all equally

ALEX PLAVEVSKI/EPFL - EFL/SHUTTERSTOCK

We can also marry that with our response to the climate crisis, by devising new ways to facilitate decarbonisation and zero-carbon trade. How we address the climate crisis is in many respects the test of whether we can rebalance again between the dynamism of the market and what's ultimately required for sustainable growth.

Talking of sustainable growth, in the UK, we have just seen the publication of the government-backed Dasgupta Review on the economics of biodiversity. It paints a bleak picture of how we have failed to value nature. Why is this such a problem for conventional economics?

The easier part of that question is about how we value an externality, a cost or benefit not incurred by a producer, such as carbon emissions. The build-up of this greenhouse gas leads to changes in our climate that, if left unaddressed, present existential consequences for the whole planet. There are ways to address this kind of thing. We're making baby steps towards putting a price on those externalities, through things like carbon prices.

The harder part is how we value nature more broadly. Let's imagine a species of a bird that itself doesn't have an economic use, but is valuable nevertheless. Are there dangers in putting a price on that bird because it encourages economic trade-offs? Say I'm going to make a lot of money by building a new factory, and it will affect that bird. Well, what if the value of my new factory is greater than the imputed value of the bird? The Dasgupta Review makes a core point that we must view ourselves as part of nature, not separate from it, and that we have been depleting our natural capital.

How do we live up to that ambition?

It's early stages, but markets are developing mechanisms that put a price on aspects of nature that will help to improve it – for example, carbon offsetting through schemes like reforestation. Companies looking to reduce their carbon footprint are increasingly interested in those types of project.



A residential area of New Delhi, India, shrouded in smog

REUTERS/DANISH SIDDIQUI

But, as the Dasgupta Review sets out, we need to establish a separate accounting system that allows us to gain some sense of whether our overall natural capital is being depleted or being added to. Then we can have an objective to add to it. Carbon pricing doesn't take account of all the other benefits we get from nature, besides its ability to draw down carbon. And it ignores our intergenerational responsibility: it doesn't take account of the value future generations will draw from that natural capital. These are ultimately not aspects of our heritage that should be traded off against shorter-term profit.

In your book, you say that new "technologies" are needed in the spheres of engineering, politics and finance to tackle climate change and the wider environmental crisis. How are we doing with those?

On climate change, I think we are getting there. We've left it very late. But we now have

engineering solutions that brilliant minds have developed and that companies have made much more economic. About two-thirds of emissions can be economically reduced today. There are pathways for the other third, but there need to be some breakthroughs; that is still in the realm of venture capital. But people recognise that if they can crack, say, green hydrogen as a fuel for trucks or direct air capture of carbon, there will be an enormous use for those and they or their company will make a lot of money. So we're finally seeing effort, capital and focus flowing into those.

On the political side, we have moved on from a world where the scale of the effort required to deal with climate change wasn't appreciated and where the effort was slow and fragmented. There is increasingly a recognition that we need to get to net-zero greenhouse gas emissions and keep net warming below 2°C, and ideally below 1.5°C. This is to the credit of those who've helped spur the change ➤

The cost of carbon

A central plank of plans to combat climate change is the principle that greenhouse gas emissions should be paid for. Governments can implement this in several different ways, from direct carbon taxes – in which governments put an explicit price on the right to emit greenhouse gases – to “shadow pricing” in the form of regulations that discourage carbon-intensive industry.

Most countries already have a piecemeal carbon tax, in the form of special levies on petrol, for example. The main aim here is generally to raise revenue. In contrast, some of the schemes afoot now, for example in the European Union and Canada, plan to impose a flat tax per tonne of carbon dioxide or equivalent, with the aim of nudging entire economies away from polluting activities. As economies adjust, the carbon price is gradually raised, with the aim of promoting a virtuous circle of lower-carbon living.

That has the potential to be very unpopular. For that reason, economists suggest the best move is to rebate the money raised to individual consumers, particularly the less well-off. It might seem pointless taking money and giving it back. But it means that products like food or fuel that are more carbon-intensive are also more expensive, and this could help change consumer behaviour – while not putting anyone at any overall economic disadvantage.

Canada’s federal carbon tax plan has all these features. Its carbon price, currently \$30 a tonne, is planned to rise to \$170 a tonne by 2030. The system is designed so that people in the bottom two-thirds of the income bracket get a rebate that pays them more than they put in, in the form of a quarterly “carbon dividend” to their bank account. *Richard Webb*

through social movements, many of them led by young people. We see 130 countries and counting that have net zero as an objective, with the US likely to soon join the club. There is broad public support for this. The UK has led the way, with a legislated commitment to net zero, as has the European Union. The politics is beginning to cascade down to companies and into the third leg, finance.

What financial technologies are needed to turn things around?

You need information, financial tools and some pricing mechanisms. With those in place, the financial market will pull forward the adjustments that are needed, recognising that net zero is a core political goal, that the engineering technologies exist to advance it and this is where people want to invest.

This is just beginning to happen at scale. Through COP26 in November, we’re looking to really accelerate this progress, to get the core of

the financial system around the world – banks, pension funds, asset managers – committed to net-zero transparency, so that people can see where institutions stand. That brings these three elements – engineering, political and financial – together, and it has the potential to be exceptionally powerful. The big caveat is that we really need it to be powerful, given how late we’ve left it.

The UK government recently failed to stand in the way of a deep coal mine being developed in Cumbria in the north of England. Are politicians still only talking the talk?

Current policies are better than previous policies, but they are still not enough. There has been big progress in that there are much clearer signals about what isn’t going to be allowed. Knowing, for example, that there will be no new internal combustion engine vehicles from 2030 in the UK and Europe sends a message to the auto industry to get on with developing electric vehicles and charging infrastructure. It tells consumers that if you buy a diesel or petrol vehicle in the latter half of this decade, you will be buying obsolescence.

That said, the Climate Change Committee, an independent advisory body to the UK government, still judges that UK policies aren’t enough to get us to net zero. It isn’t my job to defend the government, but I think later this year, maybe next, we will have additional policies that move further in that direction. What’s important for business is that there is a credible track record demonstrating that governments will do what it takes. In countries like the UK, that track record is now lengthening.

Some form of carbon pricing is central to the climate battle (see “The cost of carbon”, left). But have episodes like the *gilets jaunes* protests against fuel price rises in France shown it is too unpopular?

The problem is that a uniform carbon price is a regressive tax. The amount the less well-off pay for petrol or the carbon embodied in their food or heating is a bigger proportion of their incomes than it is for the better-off. But it is



ALAIN PITTON/PHOTO VIA GETTY IMAGES

Anger over fuel tax rises in France boiled over into the *gilets jaunes* demonstrations that began in 2018



Solar power in Chile's Atacama desert. Creating the right market conditions is crucial to scaling up green energy

"We can't self-isolate from the environmental crisis. We have to live the values that are necessary to solve it"

important to have a uniform carbon price. The solution is to rebate individuals, as Canada has done with its recently designed scheme.

Should we also be penalising polluting industries by divesting from them?

Certain industries do have huge emissions. The energy sector, steel and cement are examples. But I wouldn't advocate a blanket sale of shares in every company in, say, the energy sector because some are reinvesting their money in a green future. The companies that can do most to reduce emissions are actually some of the ones you want to back – you go to where the emissions are. The question to pose for any individual company is: what is it doing with its business strategy and investments to reduce its impact on the planet?

Every investor has to make their own judgments about who's sincere on this front

and where they draw the line between somebody who's not doing enough and somebody who deserves their backing. They also need to ask themselves if they have enough information to fully know.

Again, with COP26, we're trying to help with this through some of the plumbing-type work for the financial sector, establishing reporting requirements so that every bank, pension fund, insurance company and investor can make those judgments about whether companies are being managed in a way consistent with getting to net zero. I hope with the meeting in Glasgow, we'll get to that point. Then, hopefully, more people will be asking those questions and moving their money to places that are consistent with their values.

Do you think COP26 will succeed?

It has to. There is great momentum in civil society, and encouraging momentum in business and in finance responding to that. We've had encouraging steps taken by major countries like China, Japan and South Korea in recent months. There's the new orientation of the US administration. All of that is positive. It's a huge responsibility for the UK and, rightly, it is looking for a very high-ambition outcome. That's what the world needs. We're going to need every minute between now and November to help achieve that.

The thing that sets the climate crisis apart from the other crises of value is that failure isn't an option. Right?

Well, we don't get another shot, put it that way. Failure could happen. But, you know, financial crises tend to come along once every decade and you can learn your lessons and improve. And there, I think, we have improved in many regards. But we can't self-isolate from the environmental crisis. We have to live the values that are necessary to solve it. ■



Richard Webb is *New Scientist's* executive editor

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In a world emerging from the darkness and despair of the COVID-19 pandemic, we are looking for the next group of people who want to join us in our mission to bring light and hope through digital discovery and innovation. We need people who are committed to changing the world via world-class research that focuses on amplifying human capabilities through the use of data driven and intelligence enabled systems. The programme spans 4 years and includes an integrated Masters.

Working alongside a rich and diverse set of industrial, public and third sector partners – including Facebook, Siemens, Tata, Ordnance Survey, Amicus Therapeutics, NHS and Google – successful candidates will use a people-first approach to drive exciting, adventurous and impactful scientific breakthroughs.

The Centre, funded by the UK's Premier Science and Engineering body, the EPSRC, is housed in the £32.5M state-of-the art Computational Foundry at Swansea University. Members of our Centre will be nurtured by multidisciplinary supervisors who are globally leading research agendas in Computer Science, Mathematics, Engineering, Management, Medicine and Social Care and Law.

Candidates should have an aptitude and ability in computational thinking and methods including the ability to write software or enthusiasm to learn how to do so. While such aptitude might be evidenced by a degree in Computer Science, Mathematics or Engineering, we are building a community that aspires to have a high degree of diversity of perspective. So, if you have a background in Arts and Humanities; Social Sciences; Law; Management for instance, please be encouraged to apply.

For future AI and big data technologies to serve society and the economy effectively, they will need to be created and critiqued by a diverse and wide set of perspectives as possible: we welcome applications from anyone who feels they can help in the mission of the Centre.

This year, we have 11 fully funded places (fees plus maintenance stipend set at the UKRI rate, currently £15,285 per annum for 2020/21 for full-time students, updated each year). Places are also available for those in receipt of four-year external funding.

Applications for our Centre should be made via our website (www.swansea.ac.uk/Science/epsrc-centre-for-doctoral-training) by March 26th, 2021. There will be an information and interview event scheduled for 21st and 22nd April 2021.

For an informal discussion about your application, please contact the Centre Director. We also welcome conversations with any organisations who want to become part of our growing stakeholder community. Professor Matt Jones (Director-Enhance-CDT@swansea.ac.uk).

Puzzles
Try our crossword, quick quiz and logic puzzle **p52**

Almost the last word
From how far away is the sun no longer the brightest star? **p54**

Tom Gauld for New Scientist
A cartoonist's take on the world **p55**

Feedback
Concrete lunacy and more nominative determinism **p56**

Twisteddoodles for New Scientist
Picturing the lighter side of life **p56**

Stargazing at home

What makes an equinox?

The spring equinox gives us days and nights of the same length, right? It isn't as simple as that, says **Abigail Beall**



Abigail Beall is a science writer in Leeds, UK. She is the author of *The Art of Urban Astronomy* @abbybeall

What you need
Clear skies

THIS Saturday (20 March) marks the vernal – or spring – equinox, when the sun crosses the celestial equator, sitting exactly between the hemispheres. It also marks the start of spring in the northern hemisphere and the beginning of autumn in the southern hemisphere.

You might have heard that day and night are of equal length around the world at the equinox (hence the name), but this isn't strictly true. In an equinox, there are around 12 hours of daylight and 12 hours of night, but most places on Earth will receive slightly more daylight (see table, right).

Understanding why means thinking about sunrise and sunset. Sunrise occurs when the upper edge of the sun climbs above the eastern horizon, and sunset when its upper edge dips below the western horizon. The sun has technically risen even when only some of it is visible, and it hasn't set until all of it has disappeared.

If we defined sunrise and sunset as the time when the centre of the sun rose above the horizon and then dipped away, we would have 12 hours of daylight at the equinox. But we don't.

There are two reasons for this. First, the sun is a disc, not a point of light. This means that the middle of the sun can be below the horizon, but we still receive sunlight. On the equinox, the centre of the sun is visible for exactly 12 hours in a day. But there are a few minutes after sunset in which the rest of the sun is visible, giving us a slightly longer day.



JAMES OSMOND/GETTY IMAGES

City	Latitude	Hours of daylight on 20 March
New York City	40.73061	12 hours 9 minutes
London	51.509865	12 hours 11 minutes
Tromsø, Norway	69.6489	12 hours 20 minutes
Johannesburg	-26.195246	12 hours 7 minutes
Melbourne	-37.840935	12 hours 9 minutes
Queenstown, NZ	-45.031162	12 hours 10 minutes

The other reason concerns the refraction of light by Earth's atmosphere. At sunset, for instance, the top of the sun stays visible for a few minutes after the sun has set, because the light is bent as it travels through the atmosphere. This effect adds 6 minutes to the length of the day.

Wherever you live, the vernal equinox isn't a day but a time. This year, it is at 9.37 am GMT on 20 March. If you want to celebrate it, take a look at a sunset this week and think about seeing the sun even when it isn't actually there.

Although day and night aren't the same length on an equinox,

there are days around an equinox when day and night are very close to 12 hours each. These days are called the equilux, but when they happen depends on your latitude.

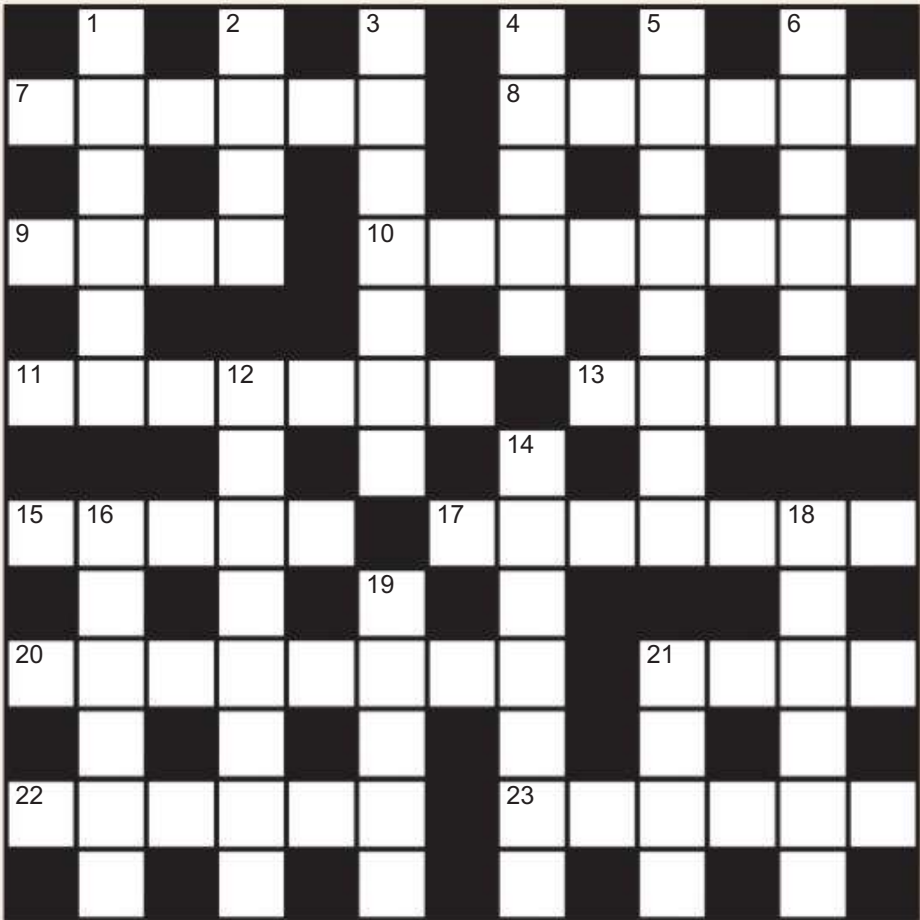
Just 5 degrees north of the equator, equilux happens on 24 February, compared with 18 March at 60 degrees north. Likewise, day and night are of almost equal length on 14 April just 5 degrees south of the equator, compared with 60 degrees south, where it happens on 22 March. ■

These articles are posted each week at [newscientist.com/maker](https://www.newscientist.com/maker)

Stargazing at home appears every four weeks

Next week
Science of gardening

Cryptic crossword #53 Set by Wingding



Scribble zone

Answers and the next quick crossword next week

- ACROSS**
- 7 Exist to carry a whale (6)
 - 8 Organic compound made from source of person's body fluid (6)
 - 9 Sand has to settle around liquid (4)
 - 10 Igneous rock has one gripped by immune system disease going round in Scottish town (8)
 - 11 Krill manure occasionally dropping in volcano (7)
 - 13 Distorts diver's affliction (5)
 - 15 Words for periods (5)
 - 17 Bond captures villain's leader, following coat in secret (7)
 - 20 Hotel in Cambridge working for spice (8)
 - 21 Lone fish (4)
 - 22 Entrance concealed by report already (6)
 - 23 Young fish to flip the bird (6)

- DOWN**
- 1 Space programme putting car behind Armstrong and Peake, at last (6)
 - 2 Tissue types include fat (4)
 - 3 Reorganised Nobel taking a year? Rubbish (7)
 - 4 Bondage sex after bath causing contraction (5)
 - 5 Treading clumsily on slope (8)
 - 6 Darwin moving towards the centre (6)
 - 12 Shellfish making odorous gas endlessly above central waters (8)
 - 14 Vegetables' ends placed around pot (7)
 - 16 Parasites finally degrade Italian food, replacing one zucchini starter with oxygen (6)
 - 18 Car supported by unknown alga (6)
 - 19 Extract metal and sulphur to make liquid (5)
 - 21 It's irrational and ridiculous to dismiss sailor (4)



Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #93

- 1 Which macropod is the only member of the *Setonix* genus?
- 2 Budd-Chiari syndrome is a rare condition affecting blood vessels and which organ?
- 3 The Andes stretch through how many countries?
- 4 English astronomer John Bevis is credited with discovering which nebula in 1731?
- 5 Knowth, Newgrange and Dowth are three large passage tombs in which UNESCO World Heritage Site?

Answers on page 55

Puzzle
set by Steven Wain
#105 Mastermind

	A	B	C	D	RESULT
1					
2					
3					
4					
5 ?					

Clearing out a friend's loft, I came across a box containing an unfinished game of *Mastermind*. The pegs weren't the normal colours, so maybe it was a pirate version.

In this game, one player sets a code (ABCD) with four pegs. The same colour may be used more than once. The second player tries to guess the code in as few turns as possible. After each guess, the setter uses small white pegs to indicate how many pegs in the guess are the right colour in the right position, and black pegs to indicate how many right colours are in the wrong position.

In my friend's version, the little pegs were grey and brown, with no clue as to whether the grey one was a "white" or a "black". The unfinished game had four guesses. Can you figure out what the right code was?

Answer next week



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AND HUMAN STUPIDITY.
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THE FORMER.
ALBERT EINSTEIN

EARTH IS ROUND
VACCINES WORK
WE'VE BEEN TO THE MOON
CHEMTRAILS DON'T EXIST
CLIMATE CHANGE IS REAL
DINOSAURS HAD FEATHERS
EVOLUTION IS A FACT

We Do Mugs Too!

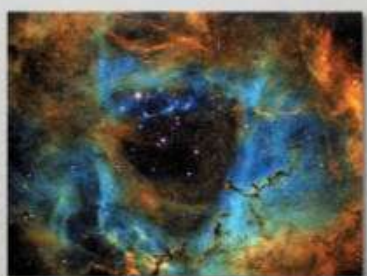
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Escape from the sun

How far would you have to travel away from the sun for it no longer to be the brightest object you could see?

Franziska Hömke

Heidelberg, Germany

How bright an object appears to an observer depends on its apparent magnitude. That, in turn, depends on its absolute magnitude and its distance from the observer.

If you boarded a spacecraft and headed towards another star, there would be a point at which the apparent magnitude of the sun would equal that of the other star. The closest such point is about 1.5 light years from Earth, between our planet and the star Sirius.

Mike Follows

*Sutton Coldfield,
West Midlands, UK*

As seen from Earth, Sirius is the brightest object in the night sky. Sometimes known as the Dog Star, it is located in the constellation Canis Major.

To look at a star is to look back in time. An eye adjusted to darkness with a pupil diameter of

“For the sun to appear as dim as Sirius, the brightest object in our night sky, it would need to be moved 1.7 light years away”

6 millimetres looking towards this constellation would intercept a remarkable 8 million photons per second from Sirius, particles of light that launched from the stellar surface 8.6 years earlier.

Sirius has a luminosity 25.4 times greater than the sun, but, because it is 8.6 light years away, its apparent brightness is 12 billion times less than that of the sun. For the sun to appear as dim as Sirius, it would need to be moved 1.7 light years away.

If we were to leave the solar system and move directly towards Sirius, and then look back at the



KESUDAPI/GETTY IMAGES

This week's new questions

Sticking power How does porridge manage to stick to non-stick pans? *Geoff Gill, London, UK*

Weak with laughter Why is it that we are stronger when we are angry, but hardly have the strength to stand up when we laugh really hard? *Samira Bendjedidi, Reading, Berkshire, UK*

sun, it would begin to appear dimmer than Sirius once we had completed 17 per cent of the journey – about 1.43 light years.

By travelling along this path, it is conceivable that another star might outshine the sun before we have travelled 1.43 light years. To be sure, we would need to know the luminosity and spatial arrangement of all local stars.

Pat Sheil

*Camperdown,
New South Wales, Australia*

The closest you could be to Earth and have another star appear brighter than the sun would be just under 2 light years towards the star Alpha Centauri A, which is just over 4 light years from us.

Alpha Centauri A is somewhat bigger and more luminous than the sun, at about 1.5 times the solar

brightness, so it would appear to outshine the sun well before you got halfway there. My estimate is about 1.8 light years would do it.

Damir Blazina

Bonn, Germany

To answer the question literally, the closest stable such point would be the side of Mercury facing away from the sun. Our star would be hidden from an observer at this point by the planet, rendering it completely invisible.

Mercury has no natural satellites, therefore the brightest visible object would probably be one of the other planets in the solar system, depending on their relative orbital positions.

Mercury's path shows high eccentricity, meaning it deviates significantly from a circular orbit. At their closest, the observer

Foods such as porridge can stick like glue to non-stick surfaces. How come?

would be only 46 million kilometres from the sun, or about one-third of the distance between Earth and the sun.

There are objects that come even closer to the sun, such as small asteroids, but their orbits are often uncertain and landing on them would be challenging. Landing on the night side of Mercury is technically feasible. Surviving there would be quite another matter.

Andrew Aitchison

Kendal, Cumbria, UK

The Chelyabinsk meteor, which exploded over Russia in 2013, was said to be brighter than the sun, as were some nuclear bomb tests.

Fear and trembling

Why do our hands shake when we are nervous?

Lewis O'Shaughnessy

Nottingham, UK

The origins of nervousness and associated shaking lie deep in our evolutionary history. Nervousness is essentially a response to stress.

Stress is associated with a powerful fight-or-flight response: our sympathetic nervous system dilates our pupils, initiates sweating and stimulates the flow of blood rich in sugar and oxygen to our muscles. The release of adrenaline into our blood perpetuates these effects.

Historically, this was essential to enable us to catch prey, escape predators or fight rivals, as these changes make the body much more ready for physical activity.

Unfortunately, the body reacts to all stress the same way and isn't able to distinguish the stress of a boardroom meeting from that of an attack by a predator. A side effect of this readiness can be tremors in our muscles as they start producing energy, which has nowhere to go other than into muscle contractions. This can



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Tom Gauld
for *New Scientist*



be exacerbated by involuntarily tensing muscles, which can also lead to shaking as it is incredibly difficult to tense a muscle for extended periods of time.

David Muir
Edinburgh, UK

When we are in a situation that we perceive as threatening, we experience a hormonal surge, particularly of adrenaline and noradrenaline, which primes our bodies to either do battle or run away quickly. This fight-or-flight response enhances our capacity to survive danger by preparing us for immediate action.

Increased tension in our muscles can cause involuntary shaking. Someone shaking with anger is getting ready for a fight, while someone cowering in a cupboard, shaking with fear, has already opted for flight.

This hyperarousal helps us survive threats and retain our potential to pass on our genes. But there is a downside. The body can initiate fight-or-flight in situations that aren't life-threatening, such

“The body views all stress the same way. It can't tell the stress of a boardroom meeting from that of a predator attack”

as work difficulties or family troubles, resulting in anxiety and chronic stress. This, in turn, promotes a panoply of physical and mental health problems.

The fight-or-flight reflex can be triggered even when the threat or implied threat isn't necessarily physical, but has the potential to harm our social status.

Bubble trouble

In carbonated water, larger bubbles oscillate as they float upwards. What causes this, and why is it only big bubbles? (continued)

John Davies
Lancaster, UK

Larger bubbles have lower pressure within them than smaller ones, making them less stiff and

so more vulnerable to distortion as they flow through the liquid. The distortion causes the upward motion of the bubbles to deviate from a straight line.

This effect is readily seen in soap bubbles blown in air. The small ones will be spherical, but large ones can assume non-spherical shapes and tend to waver.

Eric Kvaalen

Les Essarts-le-Roi, France

It is a question of the Reynolds number, used to predict flow patterns in fluids, which is related to the speed of an object, its size, and the viscosity and density of the fluid it is in.

When the Reynolds number is high enough, vortices are shed by a bubble alternately to one side then the other, causing the bubble to zigzag. At lower Reynolds numbers, vortices aren't shed at all. The fluid simply moves symmetrically around the sphere. Larger bubbles have larger Reynolds numbers, as they have both a larger diameter and a higher speed. ■

Answers

Quick quiz #93

Answers

1 *Setonix brachyurus*, better known as the quokka

2 The liver

3 Seven: Argentina, Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela

4 The Crab nebula

5 Brú na Bóinne, also known as the Bend of Boyne, in Ireland

Quick crossword #78

Answers

ACROSS **1** Island, **5** Behcet, **10** Amalgam, **11** Turista, **12** Corona, **15** Binary, **16** Alluvia, **17** Rows, **18** Lynx, **19** Squelch, **20** Arch, **22** IMAX, **25** Robotic, **27** Throat, **28** Normal, **31/32** Midwich cuckoos, **33** Cornea, **34** Sixths

DOWN **2** Sparrow, **3** Angina, **4** Dome, **5** Beta, **6** Hernia, **7** Ecstasy, **8** Saucer, **9** Larynx, **13** Aliquot, **14** Fuse box, **15** Bitcoin, **20** Asthma, **21** CB radio, **23** Mammoth, **24** Xylose, **25** Radian, **26** Coccyx, **29** Rhea, **30** Aces

#104 Soccerdoku Solution

Every team played three matches, so United drew one, and Albion won one but drew none. United conceded 0 goals, so they drew 0-0 with Town, and hence beat Rovers 1-0 and Albion 1-0. The other results were:
United 1 Rovers 0
United 1 Albion 0
United 0 Town 0
Rovers 2 Town 0
Rovers 2 Albion 0
Albion 3 Town 0

Concrete lunacy

Feedback was delighted to see the spirit of 1950s sci-fi alive and well in our news section last week with a story about building concrete towers that could stretch many tens of kilometres high on the moon (p 15).

We are far from disputing the conclusions of the team from Harvard University, that the relative lack of things such as gravity, wind, seismic motions and planning permission on the moon would allow such huge edifices. Still, we look forward to the lively debate a few decades after the towers' erection on the merits of lunar brutalism as an architectural style. At least if the decision were eventually made to blow them up again, towers on the moon would presumably just float away.

We are slightly nonplussed by another aspect of the story, however. The main purpose of the towers would be to hang solar panels off to generate energy for a lunar base. But with a 17-kilometre-high tower requiring a million tonnes of concrete, we rather wonder where the energy comes from to make the concrete. A smaller tower?

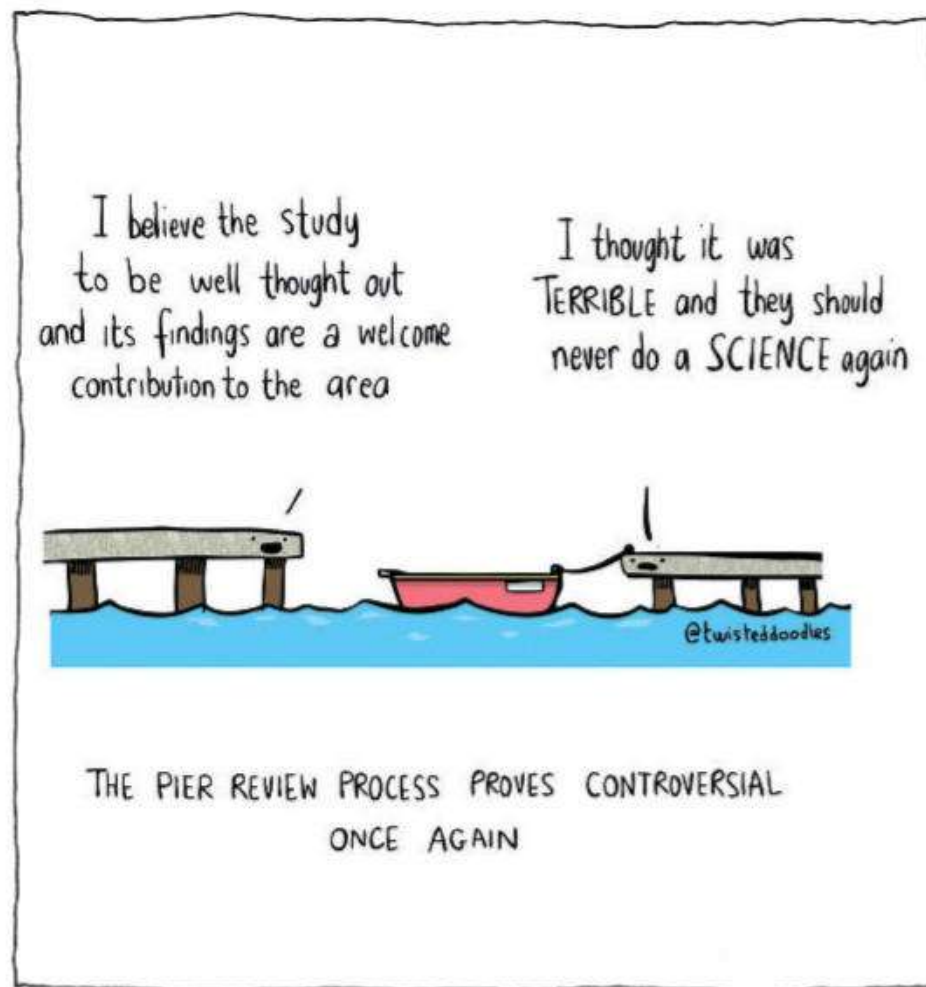
Appropriate units

We apologise to any readers left perplexed by our failure to express anything in that last snippet in multiples of Burj Khalifa[s]. After all, reader Gregg Mitchell points out, this is now the go-to unit for largeness in any number of areas: height, mass, volume, hubris.

He cites the example of the controversial Site C hydroelectric dam being constructed in his neck of the woods in British Columbia, Canada, reported by a local newspaper to have used 6 Burj Khalifas of concrete. Site C's price tag – as Gregg points out, we can only imagine sardonically – has also doubled from 5BK to 10BK.

Rather more homely and human-scale, almost, is the Sky News headline "Iceberg size of Bedfordshire breaks off from Antarctica". Ceri Brown writes in from Haverfordwest, Wales,

Twisteddoodles for New Scientist



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presumably in a fit of pique, to ask how many Bedfordshires there are in a Wales. About 16.8, Ceri – do you need that in Burj Khalifas?

Spreading the seed

In considering blowing up concrete towers on the moon, we hadn't quite considered the full range of uses they might have been put to.

A paper submitted to a virtual session of the Institute of Electrical and Electronics Engineers Aerospace Conference, "Lunar Pits and Lava Tubes for a Modern Ark", points out that life on Earth faces potential existential inconveniences, from asteroid impacts to nuclear war. Our response, it suggests, should be to construct a lunar repository of reproductive cells from humans and other species, from which we might reseed Earth after the balloon's gone up.

Having now reached the relevant point in the presentation, we see that the proposal is to establish the lunar sperm bank not in a tower, but in a natural hollow space beneath the moon's surface. So do carry on.

Don't stop moving

"The perpetual motion machine returns!", Don Simpson shouts joyously. He brings news of the TRIAD power cube, a game-changer in the world of generators whose "zero back-EMF technology allows for unimaginable efficiencies to be obtained".

Feedback has a rule of thumb for imaginable power efficiencies: start at 100 per cent and then subtract some, because thermodynamics. At least the makers of the TRIAD power cube are upfront about not being 100 per cent sure how their device

achieves "Efficiencies in excess of 400%>", besides negating the law of magnetic induction.

Sadly, the device, a snip at just £5999.99 – keep the penny, thanks – is only available on pre-order pending full development. Don't call them, they'll call you.

Shoe boot other foot

An even more joyous throng forms in our inbox at the widely reported news last week that Terry Boot has replaced Peter Foot as finance director of UK retailer Shoe Zone. Other media having exhausted the various permutative puns the story afforded, we note quietly that Foot only joined the company in July 2020. This suggests that, while perhaps good for a bit of publicity, our old frenemy nominative determinism might have its limits as a commercial strategy.

We can only hope that Boot puts his best foot forward and avoids quickly getting the... now, stop it. Thanks to our friends on four continents who sent that one in. Definitely a case of don't call us – oh, you have.

Mouths of babes

In the UK, Census Day fast approaches – or, should you be reading this after 21 March, has hurtled straight past. Roger Morgan from Presteigne, Wales, is impressed with the confidence that the UK Office for National Statistics shows in the educational attainment of the nation's youth.

Its "What you need to know" guide sets out questions that those under the ages of 5, 3 and 1 need not answer. The under-3s, for example, are exempted from the question "How well do you speak English?" – or indeed Welsh – although they are, presumably, expected to at least understand it well enough to know they need not answer it. Particularly consequential is the instruction "those under one year old do not need to answer question 13". Question 13 is "One year ago, what was your usual address?". ■



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Partha Dasgupta

Economist, University of Cambridge, and author of the UK government review “The Economics of Biodiversity”

Susan Gardner

Ocean conservationist and director of the Ecosystems Division, UNEP

Cristián Samper

Tropical biologist, president and CEO of the Wildlife Conservation Society